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RECENT PROGRESS IN PEDIATRIC SURGERY

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The great advances in anesthesia in the last decade, together with improved understanding of the principles of hydration and electrolyte replacement in infants, with the avoidance of the over hydration and edema which used to be so common, have permitted a wide and successful expansion of pediatric surgery.

One of the most dramatic advances in pediatric surgery is the conversion of the condition of esophageal atresia with tracheoesophageal fistula from one with a mortality of 100 per cent to one in which up to 70 per cent of infants can be restored to a normal existence. In 95 per cent of cases the lesion consists of an atresia of the esophagus, terminating at the level of the second to the fourth dorsal vertebra. The proximal segment is connected to the distal segment by a few muscle strands, and the distal segment connects with the posterior surface of the trachea at or near the bifurcation so that inspired air has access to the stomach through the distal segment of the esophagus. The futile efforts of the fetus to swallow amniotic fluid result in dilation and great hypertrophy of the proximal segment. The great disproportion in size between proximal and distal segments presents one of the principal technical difficulties in the operative procedure. The operation of choice is obviously division of the fistula between the distal segment and the trachea, closure of the tracheal opening and anastomosis of the two esophageal segments. This was first successfully performed by Dr. Cameron Haight, and reported in 1943, using a left extra pleural approach, subsequent operations being by a right extra pleural approach. In 1942 when Dr. Edgar Poth, who is in this audience today, was on the full time staff at Hopkins, when I was resident in surgery, he suggested this definitive operation to me and had me perform it on a baby with tracheoesophageal fistula and esophageal atresia. The operation went well and at its conclusion I dusted a substantial amount of sulfanilamide powder in the mediastinum in accordance with

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the practice of the time. Unaware of this, the pediatricians, on the child's return to the ward, administered heavy doses of sulfanilamide and the result was a blood level of several hundred milligrams per cent. The child survived several days and died of anuria with a clean mediastinum and a good anastomosis.

Diagnosis is suggested by the observation that a new born infant is bubbling spittle, and confirmed by the attempted passage of a firm radiopaque catheter into the esophagus. A soft catheter may coil in the proximal segment and falsely suggest that there is no obstruction. By using a firm catheter and by confirming the obstruction radiologically the diagnosis may be arrived at with certainty. Until operation is undertaken the head of the crib should be tilted upwards and constant suction maintained on the catheter in the dilated proximal segment. This will minimize the otherwise inevitable aspiration of saliva and the development of pneumonia which usually begins in the right upper lobe. Until recently our experience has been exclusively with the right, extra pleural approach. Recently we have begun to employ the right trans-pleural approach. There is no question but that this makes the anastomosis infinitely easier. It is somewhat disturbing that a number of the operative series reported by this method do not show mortality rates as low as some of the earlier series with the extra pleural approach.

Carcinoma of the thyroid gland in children is brought into this discussion not so much because of recent improvements in its therapy as because of the information which has been shed on its etiology in some patients. A number of reports from widely separated clinics have demonstrated impressively that there is an unusually high incidence in children with carcinoma of the thyroid of a history of irradiation of "an enlarged thymus" in infancy. There seems very little doubt but that this represents carcinogenesis as a result of irradiation, although there is presumably the remote possibility that the mass which was originally irradiated, was, in fact, an existing cancer of the thyroid. An increased incidence of cancer of the thyroid would not be expected from the use of topical application of radium to lymphoid overgrowth in the naso pharynx and has not been reported. Cancer of the thyroid in children is not a rarity, and, in fact, a nodule in the thyroid gland of a child is considerably more likely to be carcinomatous than a similar nodule in the thyroid gland of an adult. Whereas it was formerly stated that carcinoma of the thyroid in children, unlike cancer in the young in most other organs, is more benign than cancer of the thyroid in adults, it would begin to appear that, histologic type for histologic type, there is perhaps no striking difference between the behavior of thyroid cancers in children and in adults.

Immediate operation for a mass in the thyroid gland should be performed and in cancers apparently limited to one lobe, particularly the papillary type, hemithyroidectomy and radical neck dissection with postoperative irradiation has been our preferred treatment. One of the interesting things about carcinoma of the thyroid in children has been the occasional appearance of a miliary pulmonary spread with survival for many years. We are following now a girl whose thymus was irradiated in infancy, and who had an enlarged thyroid through most of

her childhood. She was demonstrated histologically to have carcinoma of the thyroid of the highly undifferentiated type 10 years ago. At least 3 years earlier roentgenograms had shown diffuse miliary pulmonary metastases. Today, 10 years after an incomplete removal of the tumor of the neck which surrounded both carotid arteries and the trachea, and after extensive radio therapy, and therapy with radioactive iodine, there is no obvious tumor in the neck. The roentgenogram of her chest has shown no increase in the tumor deposits since the first films some 13 years ago, but there appears to have been progressive fibrosis of the pulmonary bases where most of the metastases are located and progressive emphysema of the pulmonary apices. The result has been progressive loss of pulmonary function to the point at which it is obvious that the patient is doomed to die of pulmonary insufficiency for lack of adequate normal parenchyma.

Twenty years ago a discussion of pediatric surgery would have dealt very largely with bacterial infections and probably principally with empyema and with hematogenous osteomyelitis. Today, as you know, the effective treatment of the lower respiratory infections with antibiotics has made the ordinary post pneumonic empyema a rarity and almost the only empyemas which we see are those which are the result of intra thoracic surgical procedures. It is not strange that the antibiotics should make the treatment of hematogenous osteomyelitis infinitely more successful that it was in former days, but it seems to be extremely difficult to understand why the condition itself is apparently much rarer than it formerly was, although happily this appears to be true. At the same time we have met with such success in treating and preventing these formerly common pyogenic infections, which formed a substantial part of pediatric surgery not many years ago, the gradual evolution of drug resistant organisms in the population has introduced new problems. Staphylococcal pneumonia, formerly an extremely rare occurrence, has of late been seen with sufficient and persistent frequency to suggest that as our bacterial population is altered by widespread use of antibotics new diseases may well come to replace the old. At the Baltimore City Hospitals in the years 1921, 1922, 1923 and 1924 we treated a total of 8 patients who had primary staphylococcal pneumonia. In 1955 there were 13 cases and in 1956 there were 9 cases. At the Harriet Lane Home of the Johns Hopkins Hospital the experience has been similar, and in the years 1955 and 1956 there was a total of 26 of these patients treated. More than half of these children are under 3 months of age, and 85 per cent are under a year of age. The organisms which have caused these infections in the last 2 years have been characteristically resistant to penicillin, streptomycin, tetracycline, chlortetracycline and oxytetracycline. They have been sensitive to chloramphenicol, to erythromycin and to novobiocin. The dangerous situation which can be created by indiscriminate widespread use of antibiotics and the consequent emergence of resistant strains of organisms is apparent. The emerging picture of a constant see-saw struggle between organisms and antibiotics with the development of new strains of organisms and new antibiotics is reminiscent of the struggle fo existence at various biologic levels in the world of living things, or of the development of impenetrable battleship armor and armor piercing projectiles.

Staphylococcal pneumonia itself and the usually coincident septicemia are treatable with the appropriate antibiotics. There are a number of surgical complications seen in these patients, some of which require urgent treatment. Thin effusions may occur and require aspiration. Occasionally they are so massive and collect so rapidly as to cause respiratory difficulty from compression of a lung and mediastinal displacement. The immediate institution of underwater catheter drainage is required. The most characteristic and the most interesting complication of staphylococcal pneumonia is the development of pneumatoceles. While these pneumatoceles may result from emphysematous distention of the lung distal to the obstruction of a small bronchus by a plug of mucus, it is probable that in most instances a microscopic abscess of the wall of a small bronchus results in rupture of the bronchus and massive escape of air into the pulmonary parenchyma. Such pneumatoceles may be single or multiple and may at times increase in size with alarming rapidity as the result of a flap valve mechanism. It is not at all uncommon for the pneumatoceles to become apparent as the evidences of infection recede, so that a child who is afebrile and asymptomatic will have a roentgenogram showing one or several sharply demonstrated spherical areas of radiolucency but relatively little evidence of pulmonary infiltration. Either of two occurrences in connection with these cysts may require urgent surgical treatment. The cyst may rupture into the pleural cavity producing a pneumothorax and collapse of the lung on this side and sometimes a tension pneumothorax with displacement of the mediastinum. This requires immediate catheter drainage of the pleural cavity with negative pressure drainage. Perhaps more commonly the cysts increase so rapidly in size as to cause pulmonary compression and mediastinal displacement. In such instances it is necessary, after careful localization of the cyst, to insert a catheter into the cyst cavity by trocar thoracotomy and apply negative pressure drainage. In some instances it may be necessary to reinsert catheters into one cavity after another. We have had to use as many as five catheter thoracotomies in a single infant for successive cysts of one lung, with eventual complete resolution.

The differential diagnosis is easily made when the child enters the hospital with a blood stream infection and a frank staphylococcal pneumonia and then develops pneumatoceles. It is made with greater difficulty in the child who is not seen until some time later, when the history of his original infection is obscure and only the air sacs remain. If it is suspected that one is dealing with a poststaphylococcal pneumatocele in a baby who is not otherwise ill, several weeks of observation should permit one to distinguish between a congenital lung cyst and a pneumatocele. The congenital cysts never disappear, and, if drained, do not collapse or obliterate themselves. On the other hand it must be appreciated that the pneumatoceles which occur after staphylococcal pneumonia are sometimes extremely slow to clear. We have had one instance in which it has taken 18 months for a final disappearance of such a pneumatocele and others that have taken several weeks to several months. At present it is our belief that the mere existence of such pneumatoceles does not require catheter drainage

but that rapid increase in the size of the pneumatocele, respiratory distress from a distended pneumatocele, or rupture into the pleural cavity, are the indications for the establishment of drainage and suction.

An increasing variety of deformities of the chest wall are being recognized as amenable to and deserving of surgical correction. The commonest of these is pectus excavatum or funnel chest. This is a congenital, usually progressive, and often familial depression of the distal portion of the sternum. It is marked by obvious paradoxical inward inspiratory motion of the sternum, by the development of a thin chest in the anterior posterior diameter, and poor posture with protruberant abdomen, sloping rounded shoulders, and a forward thrust neck. In a very few infants this deformity has been associated with some difficulty in feeding, that disappeared following operative correction of the deformity. We have had one infant with pronounced respiratory stridor which disappeared following operation and there is a report of another such case. In most cases however, infants and children are thought to be asymptomatic although their parents have told us almost regularly after operation that the children are more vigorous and have a good deal more energy than previously and seem to eat better and have gained weight. In childhood and adolescence electrocardiographic abnormalities are often demonstrable either in arrhythmias or in reflections of the displacement and rotation of the heart. Mild degrees of diminution of the capacity for strenuous exercise are common. In a few instances this diminution of exercise tolerance becomes serious and in some patients cardiac failure results and death has been reported. Our practice is to operate upon children with this deformity whenever the deformity is severe or is known to be progressive and operation is undertaken as early as the decision is made that it will be required. The youngest patients have been about 3 months of age. The operation consists in a midline incision, subperichondrial resection of the deformed cartilages for the full extent of their deformity, division of the xiphisternal articulation and complete division of all sternal attachments except superiorly. A transverse osteotomy is performed across the sternum above the highest costal cartillage resected, the sternum fractured back and forth until it remains in good position without difficulty, and maintained there with heavy mattress sutures of silk through the bone across the osteotomy, and with numerous silk sutures in the periosteum. No external traction or fixation is employed since our second case in which the patient developed a massive infection which resulted in death. There have been no deaths in the more than 70 operations since that time and even in adults the sternum can be satisfactorily maintained in corrected position by proper suturing and without any form of external apparatus.

The most interesting of the less common chest deformities is pectus carinatum or pigeon breast. It is our experience that the prominence of the sternum is not so much responsible for the grotesque deformity which these patients exhibit and for the symptoms of respiratory insufficiency which they may have, so much as the deep concavities in the chest wall on either side of the prominent sternum. The operation which we have employed involves exposure of these cartilages by

reflecting the pectoralis major laterally and the rectus abdominis inferiorly. The exposed cartilages are excised subperichondrially, allowing for an immediate expansion of the pleural cavity. Tucks are taken in the now redundant perichondrium connecting the lateral ends of the resected cartilages or ribs in a straight line with the sternal ends. The result has been extremely satisfactory.

Ranking with the achievement of successful definitive treatment of tracheoesophageal fistula and esophageal atresia, is the development of a satisfactory operative procedure for the cure of Hirschsprung's disease and the establishment of its etiology. Previous treatment with drugs, sympathectomy and resection of bowel had all been directed at the dilated bowel which was the conspicuous feature in Hirschsprung's disease. Swenson, by careful study of patients with Hirschsprung's disease, balloon studies of the motility of the dilated and distal smaller segments and radiographic studies in conjunction with Neuhauser of the Boston Children's Hospital became convinced that the abnormality lay in the colon and rectum of apparently normal caliber, and not in the enormously dilated bowel proximal to this. He developed an extremely satisfactory technic for resection of this bowel and an anastomosis of the proximal bowel to the rectum immediately above the sphincters. This operation was brought back to England by Mr. Douglas Stevens, an Australian visitor who observed Swenson's work in Boston and was then associated with Dennis Brown at the Hospital for Sick Children at Great Ormond Street. In the specimens which Stevens resected, Bodian, pathologist to the Hospital for Sick Children, demonstrated the absence of the ganglion cells in the myenteric plexuses of the distal nondilated or contracted segments. It had been suspected for a generation or more that the disease was neurogenic in origin and a number of reports of this histologic abnormality had been recorded in infants suffering from severe constipation, but it had not previously been appreciated that this was the specific lesion of Hirschsprung's disease. The results of this operation have been extremely satisfactory. Since the resection of the rectum is carried quite close to the bowel wall there is no interference with the physiology of micturition nor any interference with sexual function in the males.

The diagnosis of Hirschsprung's disease is made on the basis of severe constipation dating from birth. It is thrown in doubt if there is a definite history that constipation did not begin until some time after birth and it is further thrown in doubt if there is any history of incontinence. Extreme degrees of constipation suggesting Hirschsprung's disease may be seen in children with behavior problems of which such abnormal habits of defecation may be the principal manifestation, in severely retarded or defective children, and in congenital cretins. The treatment of the children in the first two groups is directed towards the establishment of regular habits of elimination, and in the third group, thyroid hormone relieves the constipation along with other manifestations of the cretinoid state.

The treatment of intussusception by hydrostatic pressure reduction has been well established for more than 75 years so that it does not properly come under the heading of recent progress in pediatric surgery. It does appear to be finding

more of a place in current American surgical practice that it did perhaps a decade ago. Unlike the situation with the nonoperative treatment of most other acute abdominal conditions, in this instance the method of treatment itself permits diagnosis with absolute certainty. In our hands some 75 per cent of patients treated for intussusception by a barium enema under fluoroscopic control do not require operation and are thus saved the morbidity of incision and anesthesia and resultant prolongation of hospitalization. In those patients in whom the intussusception has not been completely reduced by barium enema it is easily exposed and treated through a small McBurney incision. It is conspicuous in all series of patients treated by hydrostatic pressure reduction that gangrenous bowel requiring resection is rarely encountered. This can hardly be explained in any other way than by the assumption either that surgeons operating for intussusception have often resected nongangrenous bowel or that the injury to the bowel requiring resection was produced not by the intussusception itself, but by the trauma of the operative reduction. Reduction of gangrenous bowel or perforation of bowel has not occurred with the barium enema in our experience and it is obvious that the very factors which produce gangrene are those which produce irreducibility and a pathologic and experimental study of the nature of intussusception discloses that the gangrene occurs in the intussusceptum whereas, of course, the stress of the pressure of the barium enema is borne by the intussuscipiens. Specific lesions causing intussuception such as a Meckel's diverticulum or a polyp will, of course, be missed in patients who have barium enema reduction, but they are not in themselves hazardous lesions, and no harm results. Furthermore, they are uncommon in the infants among whom the majority of intussusceptions occur.

As soon as the diagnosis of intussusception is made or suggested, the patient is posted for operation and the operating room told to send for the patient. The patient is taken at once to the fluoroscopic room, the stomach is emptied, the catheter left in the stomach, intravenous fluids or blood are given as indicated, and while these are running a Foley balloon catheter is inserted into the rectum, the balloon distended, pulled down against the levators, and the buttocks strapped together. An ordinary mixture of barium is allowed to run freely into the rectum from a height of no more than 3 to 3½ feet and the reduction of the intussusception observed at intervals under the fluoroscope without manipulation. In our series of 72 patients with intussusception the single death, previously reported, was in a child in whom the intussusception could not be budged by enema and who was taken at once to the operating room and in whom it is apparent from the operative note that nonviable bowel was reduced and not resected.

Inasmuch as the bowel may be viable and reduceable after even several days of intussusception and inasmuch as there is little or no risk of reduction of gangrenous bowel or of perforation we apply this method of treatment to all children with intussusception. While it is performed in conjunction with radiologists and pediatricians the actual procedure is administered and controlled by

the surgeon who has already posted the case for operation and who is prepared to operate if reduction is incomplete or if completeness of reduction is not certain. Satisfactory reduction of the intussusception is confirmed by—

(1) Free filling of many loops of ileum.
(2) Passage of feces or flatus.
(3) Disappearance of the mass.
(4) Improvement in the child's general condition.
(5) Recovery by enema of charcoal instilled through the stomach tube.

SUMMARY

Perhaps the most significant advance in pediatric surgery has been the recognition that with proper preparation, anesthesia and surgical technic infants and children will tolerate operations of very great magnitude. No longer are operations postponed solely to allow the subject to grow larger, and staged procedures are rarer than formerly. In general, in those conditions for which satisfactory procedures have been developed, the definitive operation is performed as soon as the indication for it is established.

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SUBTOTAL GASTRIC RESECTION FOR PEPTIC ULCER OF STOMACH AND DUODENUM: A FIVE TO TEN YEAR FOLLOW-UP

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We are reporting 100 consecutive cases of subtotal gastric resections done for benign peptic ulceration in men, over a period of 5 years, beginning June 1946, followed for as long as 10 years. These were done at the Veterans Administration Hospital, Dallas, Texas, by various members of the surgical staff. The sites of ulceration were duodenal in 74 patients, pyloric (duodenal) in 10 patients, jejunal in 4 patients and gastric in 12 patients. The first follow-up was completed in 1951 and the second in 1956. Table I indicates the completeness of the follow-up. During the period of 1946 to 1951, most patients were re-examined at 3 months, 6 months, 1 year, 2 years and 5 years. Thereafter, follow-up was less complete and final attempt at evaluation was made in 1956, and actually some patients were seen in 1957.

The ages of these men varied from 21 to 80 years with the greatest incidence between the ages of 30 and 59 years. This represents a plateau, as can be seen in table II.

The duration of symptoms varied (see table III) with the longest record of symptoms being 40 years. The majority are in the 6 to 10 year group.

Ninety-three of the patients complained (see table IV) of epigastric pain; in 6 this pain radiated to the back.

The epigastric pain was to the right of the midline in duodenal ulcerations with radiation to the right flank if there was pancreatic involvement. In gastric ulceration, most of the discomfort was to the left of the midline, whereas the pain was sharply localized to the left hypochondrium in the case of the jejunal ulceration following previous subtotal gastrectomy. Nausea and emesis were frequently present, but vomiting was more common. The vomiting was associated with periods of obstruction with pyloric stenosis or more commonly was a product of gastric decompensation. This could best be relieved by an indwelling gastric tube. It never ceases to be amazing that a compensated stomach is able to force food and fluid through a tiny pyloric orifice that will barely admit the tip of a hemostatic forcep. As was expected, bleeding was recorded in the history in 59 patients as manifested in some form or other. Forty-three gave a history of hematemesis, 38 melena, and 13 had what was considered massive bleeding. We believe that any patient who has bled sufficiently to manifest evidence of

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hypotension or requires a transfusion of blood may be said to have bled massively. Twenty-two gave a history of previous perforation and 7 of these were multiple. One patient had a history of 3 perforations and 5 had a history of 2 perforations. Twenty-five gave a history of pyloric obstruction at some time.

Indications for Subtotal Gastric Resection: A careful review of the patients indicated that by far the greatest indication (see table V) for operation was one of intractability which occurred in 49 patients.

This term indicates that the patient did not follow his ulcer regime, either through inability to secure the food required such as traveling salesmen; or that he was constitutionally unable to discipline himself, despite careful urging; and finally, those patients who responded in the hospital to a careful medical regime but were unable to withstand the stress of their usual occupation, even on a proper diet. It is frequently stated that "the patient was put on an ulcer regime", but we soon began to believe that even this designation required care-

TABLE I

Follow-up status of one hundred patients with subtotal gastric resections done for peptic ulcer in 1946–1951

	1951	1956
Total number followed	95	71
Lost to follow-up	0	22
Died in hospital after surgery	3	3
Late deaths of unrelated causes	2	4
Total	100	100

TABLE II

Age distribution

Age	Number of Cases
20–29 years	13
30–39 years	29
40–49 years	21
50–59 years	28
60–69 years	8
80 years	1

TABLE III

Duration of symptoms

0–5 years	31 cases
6–10 years	38 cases
11–15 years	13 cases
16–20 years	8 cases
Over 20 years	9 cases
40 years	1 case

TABLE IV

Symptoms

Epigastric pain		93
Radiating to back	6	
Emesis		75
Nausea		62
Bleeding		59
Hematemesis	43	
Melena	38	
Massive	13	
Obstruction		25
Perforation of ulcer		22
Multiple	7	

ful qualification. We decided that this meant absolute mental and physical rest, amphogel, milk and cream, and even Banthine in the acute stage, and later more activity and enlargement of this diet. Smoking and coffee drinking are absolutely contraindicated and such intolerance was frequently volunteered by the patient. Twenty-three gave evidence of progressive ulcer disease with increasing symptoms, more pain and failure to respond to conservative management. It soon became evident that any patient who had a perforation with further difficulty on conservative management was a candidate for surgery. It is our opinion that any patient who has had a perforation with subsequent symptoms, should have a resection done without hesitation. Obstruction is an obvious indication and occurred in 25 patients.

Of the 100 patients, 59 gave a history of bleeding of which 43 had hematemeses, 38 melena, and 23 had both. Thirteen bled massively and 3 of these bled massively 3 times. Of the 43 who had hematemeses, one had this occur 3 times, one 2 times, and the rest once. This strongly indicates the severity of this problem, as bleeding may be fatal at any time. We are inclined to think that any patient having bled once, especially, if massively, should probably have a gastric resection. It is in this group that vagotomy should not be employed and certainly not while actually bleeding. In 24, the bleeding was of enough severity to be considered the primary reason for the resection, and of these, 12 bled massively. Actually, only 2 patients represented massive uncontrolled bleeding requiring resection. We believe that any patient with a bleeding peptic ulcer who, after initial replacement of his blood loss, continues to bleed at such a rate that more than 500 ml. of whole blood each 8 hours is required to maintain his blood pressure at normal levels, is a candidate for resection and should be operated upon promptly. A preoperative diagnosis based on roentgenographic evidence is desirable and barium study should be done as an emergency procedure in such instances.

Jejunal ulcers occurred in 4 patients, 2 after gastroenterostomy, one after gastric resection and one after gastric resection and vagotomy. Bleeding was the common denominator and massive in 2 instances.

The question of gastric carcinoma always enters the discerning physician's mind in any patient with a gastric ulceration, and in this group this occurred

TABLE V

Indication for operation

Intractability		49
Progressive ulcer disease		23
Obstruction		25
Bleeding		24
Massive	13	
Gastric ulcer		12
Jejunal ulcer		4

12 times and in each instance was considered the indication for resection. Obviously, none of these proved to be gastric carcinomas, but the index of suspicion must remain high. An added factor in favor of such an attitude is the high rate of good results of gastric resection for gastric ulcer and the lack of mortality or complications. Even the ardent supporter of vagotomy does not advocate vagotomy for gastric ulcer, since this does not respond as well to that particular mode of therapy as does the duodenal ulcer. It is apparent that a combination of indications were frequently present as evidence of a need for subtotal gastrectomy. Bleeding was the single indication in 10 patients, obstruction in 11, progressive ulcer disease in 15, intractability in 18, the question of carcinoma in 2, making a total of 56 definite single reasons. The rest were combined indications for subtotal gastrectomy.

Previous surgery had been done in 10 patients (see table VI) exclusive of repair of ruptured ulcers. Of these procedures, 7 were gastroenterostomies, one vagotomy, one subtotal gastric resection, and one subtotal gastric resection and vagotomy. The latter 2 procedures were done for massive bleeding. One of these had severe multiple jejunal ulcers develop and made it necessary for further resection to control the bleeding.

At first polya, retrocolic, proximal loop to lesser curve anastomoses were done in 8 patients using a midline incision. Subsequently, this was abandoned in the last 92 patients for the Hofmeister modification. The resection consisted of two-thirds to three-fourths removal of the distal stomach to include the lesser curvature. A retrocolic anastomosis was done with a small stoma (2 fingers). In 3 patients, associated vagotomy was done. One resection was done with afferent loop to the greater curve, and 3 were antecolic. Ordinarily, general anesthesia was used with endotracheal airway for control of respiration to eliminate excessive diaphragmatic motion. In most cases, the use of d-Tubocurarine in moderate, repeated intravenous injections provided adequate relaxation in the lighter planes of surgical anesthesia, and allowed a shorter postanesthetic recovery period. Blood replacement was begun early and was liberally employed. Preoperatively a short Levine tube was inserted into the stomach with Wangensteen suction and allowed to remain until audible intestinal peristalsis was evident. Postoperatively, liquids were then given as tolerated and the diet increased with frequent small feedings, and the patient was made ambulatory the first day.

Three patients died in the hospital, one of afferent loop obstruction and

pseudomembranous colitis, one of acute yellow atrophy of the liver due to homologous serum reaction, and one from peritonitis due to aerogenes and hemolytic staphylococcus albus. The source of this infection was never determined at autopsy. All 3 patients were examined post mortem. The afferent loop obstruction syndrome has been reported by Wangensteen. He has emphasized the exercise of care to avoid undue rotation of the stomach in the mesentery of the transverse colon and a small cuff at the anastomotic line. We have added the precaution of placing the Levine tube through the anastomosis into the proximal limb. This has prevented further difficulties in this direction.

Postoperative complications occur in the wake of a procedure of considerable magnitude, such as done on these patients. These have been summarized in table VII.

The problem of duodenal fistula in resections for duodenal ulcer is a difficult one. Persistent efforts at removal of the ulcer should not be made if there is danger of having an insecure closure unless one wishes to have a catheter in the stump or leave a drain down to the suture line. One occurred in a man operated upon as an emergency for massive bleeding. He had bled down to 3 grams of hemoglobin and 1,700,000 red blood cells per cu. mm. He was transfused and operated upon. The ampulla was found on the edge of the ulcer, and on cannulating the common duct it was found constricted. A urethal catheter was left through the common duct and the duodenal stump closed. The fistual was drained. Three months later a choledochojejunostomy was necessary to correct the common duct stricture. He recovered and has gone to work. One patient developed as abscess in the right upper quadrant connecting to the duodenum 6 months later. This was successfully treated by adequate drainage. Outside

TABLE VI

Previous surgery

Gastroenterostomy	7
Vagotomy	1
Repair perforation	22
Subtotal gastric resection	1
Subtotal gastric resection & vagotomy	1

TABLE VII

Immediate postoperative complications (hospital)

Afferent loop obstruction	1
Stomal obstruction (temporary)	1
Intestinal obstruction	1
Intravenous clotting	1
Wound infections, minor	3
Duodenal fistulas	2
Leak of bile after choledochotomy	1
Jejunal ulcer	1
Bleeding from suture line requiring transfusion	1

of these 2 patients, there has been no immediate difficulty with the duodenal stump in resections for duodenal ulcer. We belive that in the majority of patients it is possible to manage this problem. In 2 instances, we have though it necessary to cannulate the common duct to prevent injury to it. One instance has been described above. On another occasion we have intubated the duct during surgery to prevent common duct injury in a low lying duodenal ulcer resection. The duct was primarily closed, but serious bile leakage occurred on the third day postoperatively. A T tube was inserted for several days and then removed without difficulty. The patient recovered completely. We now leave a urethral catheter in the duct for several days to prevent this occurrence. We believe that the cannulation of the common duct is very important to avoid injury to it during subtotal resection for duodenal ulcer where there is any question of its involvement. Stomal obstruction occurred in one patient. This was temporary and responded to conservative management of gastric suction. One patient developed obstruction following a subtotal gastric resection. This was done for a duodenal ulcer with excision of the jejunum at the site of previous gastroenterostomy. The gastrojejunostomy was then done distal to the end to end anastomosis of the jejunum, isoperistaltic, and retrocolic Hofmeister type. He developed obstruction unresponsive to conservative treatment and required a second operation. This was done 4 days later because of excruciating abdominal colic which proved to be intestinal obstruction due to volvulus of the jejunum distal to the anastomosis. He lost weight rapidly and a subsequent jejunostomy was required for feeding purposes. He then completely healed. One patient had phlebothrombosis and this was treated with femoral vein ligation. Although every attempt was made to secure hemostasis in the anastomotic line by individually transfixing gastric submucosal vessels and ligating small bowel bleeders, one patient had enough bleeding into the stomach to warrant transfusion. The bleeding then ceased spontaneously. This patient had a retrocolic Hofmeister resection for duodenal ulcer. The patient who developed a jejunal ulcer will be discussed later.

RESULTS

The main causes for poor results were marginal or jejunal ulcers, dumping, digestive symptoms and inability to gain weight.

JEJUNAL ULCERATION

In the 5 to 10 year follow-up, there were 8 patients in whom the diagnosis of jejunal ulcer was suspected. The diagnosis was based on recurrence of symptoms, usually left upper quadrant discomfort and localized tenderness, gastrointestinal bleeding and roentgenologic visualization of an ulcer fleck. The latter was not considered mandatory to the diagnosis. Three required further surgical procedures whereas the diagnosis was presumptive in the rest and the treatment conservative. This usually included the use of banthine or probanthine. Those requiring operative treatment made this evident by the third year after gastrectomy. The procedure utilized in 2 patients was reresection. One patient merits special mention because of his unusual course.

TABLE VIII

Late complications in 71 patients (1956)
(More than one complication occurred in several patients)

Jejunal or marginal ulcers		8
Proved	3	
Not proved	5	
Dumping		13
Mild	9	
Moderate	1	
Severe	3	
Severe weight loss		1
Anemia		2

Case 48. This was a 30 year old white man who was first seen by us Oct. 3, 1946. A condensed summary follows:

1. Recurrent ureteral and kidney stones since 1942 with several operations for removal of stones as late as 1947.
2. Parathyroid tumor removed in 1944.
3. Onset of epigastric symptoms which led to a diagnosis of duodenal ulcer in 1942.
4. Small pituitary tumor depressing the floor of the sella turcica, eroding and spreading the clinoid process laterally, treated with x-ray.
5. Development of hypoglycemia and hemiparesis with a diagnosis of pancreatic adenoma in 1945. Three islet cell adenomas were found and removed.
6. Recurrent bleeding from duodenal ulcer with epigastric distress, occasional nausea and emesis not responsive to medical management since 1942.

Feb. 17, 1947—Subtotal gastric resection, polya, retrocolic anastomosis, for duodenal ulcer with obstruction.

Feb. 27, 1947—Recurrence of ulcer symptoms.

April, 1947—Jejunal ulcer seen on x-ray.

May 29, 1947—Transthoracic vagotomy with healing of ulcer.

March, 1955—Reresection for bleeding of lesser curvature gastric ulcer and pancreatic cystogastrostomy for pancreatic cyst.

May, 1955—Total gastrectomy with splenectomy and colon pouch substitution for recurrent bleeding. Excision of pancreatic adenoma.

7. He developed a right iliac mass which on biopsy on Sept., 1956 was reported as a fibrosarcoma.
8. He died Oct., 1956 with carcinoma of the pancreas with metastasis.

This unusual case terminating in a necessity for total gastric resection for ulcer diathesis represents one of the more "malignant" phases of duodenal ulcer disease. This patient was obviously unique in his course.

The remaining 5 patients were treated conservatively. It is of considerable interest that 3 developed these symptoms after 6 years. There are not enough patients in this group to evaluate the significance of the time of onset. However, with the exception of one unusual patient it apparently requires 2 years for the development of this complication. The surgical treatment most favored was reresection. This seemed adequate therapy except for the exceptional patient. In all instances, the original location of peptic ulceration was duodenal. Preoperative and postoperative acidity determinations with Histamine as well as total night secretion were done in a large number of the patients. The average

preoperative free acid was 75.3 degrees with a maximum of 222 degrees with histamine stimulation. Postoperatively the average was 41.6 degrees. The night secretion averaged 1038.7 cc. with a maximum of 2200 preoperatively. Postoperatively this fell to 454.7 cc. In 54 there was no free hydrochloric acid detected postoperatively with histamine and none of these developed a jejunal ulcer. These patients apparently had the least number of complications on follow-up which was carried on from 1946 through 1951.

Dumping: This syndrome consisted of sweating, faintness, desire to lie down, dizziness, nausea, epigastric fullness or discomfort after eating in some combination. This occurred in 10 of the 100 patients followed up in 1951 and none was disabling to the patient at that time. It could be rather easily avoided by lying down, restricting the amount ingested, especially fluids during meals. Early multiple feedings were effective and by 6 months postoperatively most could eat 3 meals a day with snacks in between. However, by 1956 in a follow-up of 71 patients still alive, there were 13 classified as having dumping. It is of interest that of the first 10 who developed their symptoms from 6 months to 2 years, only 2 persisted in mild dumping, having now been followed 9 years after gastrectomy. Of the 13, 9 were considered mild, 1 moderate and 3 severe. The latter 3 were considered poor results and the dumping has led to marked disability. It would appear that of all the evaluations, that of dumping depends upon not only the objectivity of the surgeon but the *motivation* of the patient. The importance of this evaluation is to realize that such a complication occurs, and that it is relatively frequent. Digestive disturbances are difficult to evaluate but were considered to be present in 22 patients, variously represented by indigestion, occasionally nausea, emesis or diarrhea. These were not considered significant but could have been catalogued as minor dumping. If so this would represent a total of 35 (22 plus 13) who had some dumping.

Weight loss is a significant complication and is related to the extent of gastric resection and the remaining gastric pouch. Of 60 patients reviewed carefully concerning preoperative and present (1956) weight, 35 lost weight, 20 gained weight and 5 remained the same. In addition 24 were not working after resection in 1956, 29 did light work, and 15 did some form of heavy labor. We are most concerned about the 24 who did not work at all. Analysis of the reasons for not working indicated that only 11 were disabled as a direct consequence of their gastric operation. In 4 no cause except weakness could be found, 4 had dumping, 1 had drug addiction and a previous jejunal ulcer. One had severe weight loss following reresection of jejunal ulcer following subtotal gastric resection for duodenal ulcer. The matter of weight maintenance after subtotal gastric resection is usually directly related to the extent of resection and one must be careful not to remove too much stomach. One had anemia after resection requiring treatment. In the first comprehensive review in 1951, anemia of significance had occurred in 3 patients despite instructions to take ferrous sulfate 0.3 grams t. i. d. one week out of each month. Review in 1956 found only 2 had unexplained anemias. One of the cases in 1951 was lost to follow-up and one had cleared up by 1956. One persisted from the 1951 follow-up with a severe marked hypochromia re-

TABLE IX

Results

	1951	1956
Number of cases followed	95	71
Satisfactory	90	60 (84.5%)
Unsatisfactory	5	11 (15.5%)

quiring occasional transfusion. One developed since 1951. This patient was explored and no cause for the anemia found. Obviously, these could be blood loss anemias although one has been persistent for 7 years without explanation and may be a direct result of gastric resection. At the end of the 1951 evaluation of 100 cases of subtotal gastric resection 90 patients were considered as good results of the few months to 5 years follow-up.

Re-evaluation of the remaining 71 reviewed in 1956 of the 5 to 10 year follow-up would indicate some change in the results. There were 84.5 per cent satisfactory results with 15.5 per cent unsatisfactory results in 1956.

The evaluation of these results was on the basis of complications such as dumping and jejunal ulceration, disabling symptoms and ability to work. A word must be said about the difficulty of *objectivity* on the part of this particular group of patients especially in regard to their symptoms and ability to work. This may have reduced the number of satisfactory cases and it is our belief that it did. However, we feel certain that we can say that at least 85 per cent satisfactory results can be anticipated with subtotal gastric resection with the proper objective indications. This can be done with a mortality of 3 per cent, even when including emergency as well as elective surgery done by several surgeons in a standard method.

SUMMARY

One hundred consecutive cases of subtotal gastric resections were done for peptic ulceration of the duodenum (74 patients), pylorus (10 patients), jejunal (4 patients), and stomach (12 patients) with a 3 per cent mortality. These were done from 1946 to 1951 and have been followed through 1956. The patients were males and veterans between the ages of 21 and 80 years, having had symptoms for as long as 40 years. These symptoms consisted mainly of epigastric pain, nausea, emesis, bleeding and pyloric obstruction. 32 had previous surgery, including gastroenterostomy, vagotomy, and subtotal gastric resection. Significantly, 22 had perforations, and 7 of these had multiple perforations. Although any one patient frequently had several indications for subtotal gastric resection, bleeding was the single indication in 10 patients, pyloric obstruction in 11, progressive ulcer disease in 15, intractability in 18, and the question of carcinoma of the stomach in 2. It is apparent that most patients having one perforation of a duodenal ulcer come to surgery, and certainly those with 2 perforations.

Complications after subtotal gastric resection do occur. When complications occur, they tend to be serious. Serious complications were: afferent loop obstruc-

tion (1), intestinal obstruction (1), phlebothrombosis (1), duodenal fistulas (2), bile leak from choledochotomy (1), and jejunal ulcer (1). The latter occurred in a most unusual case. Most complications are preventable with experience. Jejunal ulceration is a real problem following subtotal gastric resection. By 1956, there were 8 significant jejunal ulcers, 3 of which were proved. These usually develop after 2 years, and declare the necessity for surgical treatment by the third year. We have chosen to utilize reresection of the stomach for this purpose. A complicated case is reported in some detail. Dumping is a significant problem and occurred in 13 patients at last follow-up (18.3 per cent) of which 3 proved to be severe. If one includes digestive disturbances as a manifestation, there were 22 more patients making a total of 35 patients or 50 per cent. Loss of weight or failure to maintain preoperative weight occurred in 35 patients but was significant in only one patient. This complication is related to the extent of resection. Anemia does occur after gastric resection, but usually is no problem if not due to blood loss.

Ninety per cent satisfactory results were evident in the 1951 follow-up and 84.5 per cent satisfactory results in the 1956 follow-up. It must be concluded that subtotal gastric resection is one of the palliative operations for ulcer, especially duodenal. On the basis of this conclusion, a modest resection rather than a radical one should probably be done.

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GASTRIC RESECTION: A DEFINITIVE TREATMENT FOR PERFORATED PEPTIC ULCER

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This discussion is in effect a continued report of a practice of employing subtotal gastrectomy as a definitive treatment of gastroduodenal ulcer perforations.[10] Our initial experience with this procedure occurred in 1947, when we were confronted with 2 patients who had had recurrent perforations. Both of these patients were seen relatively early. About the same time we had 2 perforated carcinomas of the stomach. The very satisfactory manner in which these people progressed postoperatively gave us some confidence in the practice of resecting perforations, and caused us to believe that this catastrophic development might well be treated definitively when presented.

We were familiar with the high regard which certain Continental surgeons had expressed for this practice. Judin had reported in 1937[13] and again in 1939[14] respectively 331 resections for perforations with a mortality of 7.8 per cent and 937 cases with a mortality of 8.9 per cent. Other European surgeons [6, 11] reported smaller groups of cases with very low mortality.

In 1933, Graves[11] reported a series of his own resections for perforation and he reviewed the reports of the Continental surgeons advocating this more extensive surgery. He stated that his report was offered as a matter of interest, but he hesitated to completely endorse the procedure of resecting perforations. Strauss,[24] in 1944, reviewed the literature and urged the practice of partial gastrectomy for perforations in selected cases, stating that the operation could be accomplished without undue difficulty and with an anticipation of permanently good results. Bisgard[3] was one of the early American surgeons who advocated gastrectomy as a selective definitive treatment for perforated gastroduodenal ulcers. Bisgard's early analysis is interpreted to mean that he thought that this definitive procedure might be done primarily without undue mortality. From his own cases and a review of the literature, he emphasized the frequency of perforations in gastric carcinomas.

In 1940, DeBakey[8, 9] reviewed the subject of perforated ulcers in much detail. He studied his own cases and cases at the Charity Hospital, and he accumulated a large number of cases from the literature. DeBakey's conclusions would indicate that he thought at that time that many of the perforated ulcers could be resected safely with no undue mortality. Timpone and Gross[25] reported a series of 16 gastrectomies for perforations without mortality. They recommended the general employment of gastrectomy for perforations, except in rare instances. Turner,[26] in 1952, reviewed a group of 224 cases of perforated ulcers treated at the Presbyterian Hospital in New York. His review emphasized the same

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relative dissatisfaction with simple closure for the treatment of perforated ulcers, on the grounds of the failure of the simple closure to effect a permanent cure in a large percentage of these perforated cases. Turner advocated cautiously the closure of perforated ulcers with a plan that they should be resected as a definitive procedure before such patients were discharged from the hospital.

Cooley, Jordan, Brockman and DeBakey,[7] in 1954, reported 112 cases of perforated gastroduodenal ulcers treated by gastrectomy with a mortality of 4.5 per cent. In the same report, 70 patients were treated by simple closure with a mortality of 8.6 per cent. Their conclusions were that a subtotal gastrectomy might be employed with a sufficiently low mortality and morbidity as to justify its use as a primary treatment in acute gastroduodenal perforations.

CLINICAL MATERIAL STUDIED

Our hospital is located in a relatively rural community. Not more than 10 per cent of the people whom we see come from the immediate territory. This means that the time lapsing between emergency and surgery must necessarily be greater than that period required for patients to be admitted from an urban center. Our cases averaged 7.2 hours from the time of perforation to the time of surgery. Since 1947 we have been responsible for 89 resections done on perforated

TABLE I

Comparison of mortality, postoperative hospital stay and results

	Elective Gastrectomy	%	Gastrectomy For Perforation	%
Total	287		89	
Operative deaths	8	2.8	0	0
Average P.O. day discharge	13.3		12.0	
Recurrences	23	8.4	3	3.4
Required Surgery	10	3.5	2	2.2

TABLE II

Comparison of complications

	Elective Gastrectomies (287)	Gastrectomy For Perforation (89)
Respiratory	15	3
Wound infection	15	7
Wound dehiscence	11	4
Delayed stomal opening	7	2
Duodenal stump leakage	11	3
Thrombophlebitis	7	0
Intra-abdominal abscess	2	0
Dumping	8	3
Total	76 (26.5%)	22 (24.7%)

TABLE III

Time lapse between perforation and surgery of 49 cases of resection
(17 walled off cases excluded)

Minimum to Maximum	Average
2-24 hours	7.2 Hours

TABLE IV

Sex ratio, 89 cases of resection for perforation

Males	80	89.9%
Females	9	10.1%
Total	89	

TABLE V

Location of ulcer, 89 cases of resection for perforation

Location	Number of Cases	%
Duodenal	56	62.9
Gastric (2 malignant)	27	30.3
Pyloric	6	6.8
Total	89	100.0

TABLE VI

Previous ulcer complications in resected perforations and elective gastrectomy

Previous Complication	In 66 Resected Perforations	In 287 Elective Gastrectomy
Surgery:		
Closure of perforation	3 (4.5%)	35 (12.2%)
Gastric resection	0	11 (3.8%)
Gastroenterostomy	0	16 (5.6%)
Bleeding	4 (6.1%)	42 (14.6%)
Obstruction	2 (3.0%)	14 (4.9%)
Total	9 (13.6%)	118 (41.1%)

ulcers. Twenty-three of these cases were supplied us by our exresidents in 1947 and 1948; these men maintained an interest in this procedure after they had located in territories near us. This group of supplied cases will be used only in our figures as to mortality. Since 1947 we have been directly responsible for 66 resections done in our own hospital for perforated ulcers, and it is from this latter group that we have drawn our principal deductions. It will be of interest to state that 24 of our own cases have been done by third and fourth year residents.

TABLE VII

Mortality of conservative treatment of perforated ulcer

	1938–1947			1947–1956		
	No.	Mortality	%	No.	Mortality	%
Total	53			17		
Simple closure	52	10		16	1	
Conservative treatment without surgery	1	1		1	1	
Total (per cent)		11	20.7		2	11.8

TABLE VIII

Follow-up comparison of elective gastrectomy, resected perforations and simple closure in 10 year period

	Simple Closure (14 Cases)	Resected Perforations (66 Cases)	Elective Gastrectomy (287 Cases)
Asymptomatic	4 (28.5%)	48 (72.7%)	210 (73.2%)
Dumping syndrome	0	3 (4.5%)	8 (2.8%)
Recurrent ulcer	7 (50.0%)	3 (4.5%)	23 (8.0%)
(Required surgery)	(4)	(2)	(10)
Lost in follow-up	3 (21.5%)	12 (18.3%)	46 (16.0%)
Total	14	66	287

TABLE IX

Type of surgery and location of ulcer as related to recurrences

	Elective Gastrectomy (287 Cases)		Gastrectomy For Perforation (66 Cases)	
	No.	Recurrences	No.	Recurrences
Billroth I—For:				
Gastric ulcer	36	3	7	1
Duodenal ulcer (including pyloric)	38	2	3	0
Total	74	5	10	1
Billroth II—For:				
Gastric ulcer	51	3	15	0
Duodenal ulcer (including pyloric)	143	12	41	2
Marginal ulcer	19	2	0	0
Total	213	17	56	2

ANALYSIS OF CASES

For the purpose of emphasis, we are dividing our cases over a 10 year period into three separate groups. From 1947 through 1949, we had 25 perforations with 12 simple closures and 13 resections, an incidence of resection of 52 per

Comparison of per cent resections for perforations in three distinct periods
(Total—83 cases of perforation with 66 cases of resection—79.5%)

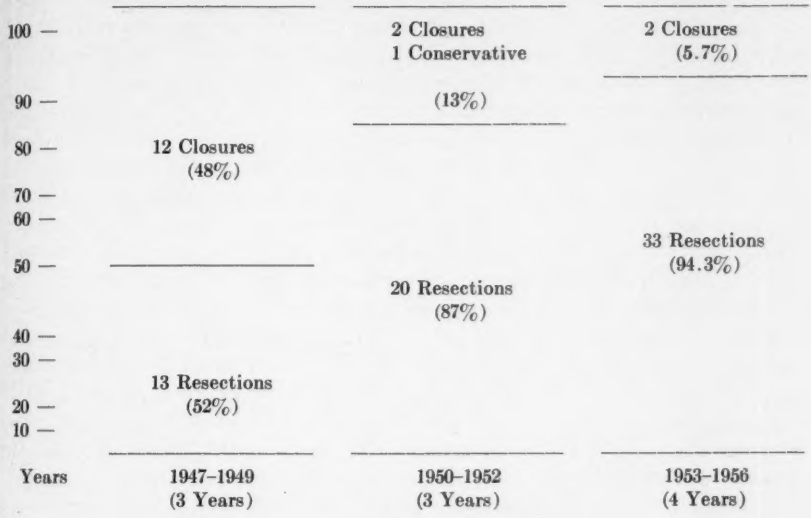

FIG. 1

cent. In the 1950–1952 period, we had 23 perforations with 20 resections, an incidence of resection of 87 per cent, two closures and one patient treated conservatively with suction. In the 1953–1956 period, we had 35 perforations with 33 resections, 94.3 per cent incidence of resection, and two closures. This analysis about typifies our reaction today towards this problem. Nothing has occurred during this 10 year period to discourage our frequently stated opinion, that perforated gastroduodenal ulcers may be safely resected, except in that group of patients where any type of surgery is undesirable.

DISCUSSION

We are acutely aware of the fact that 89 resections for perforated ulcer without a mortality does not prove that this procedure should necessarily be adopted as an answer to this hazardous problem. We do believe, however, that it establishes a trend which is well worth consideration. It has been frequently stated that the occurrence of a perforated ulcer indicates the virulent character of the ulcer. One hesitates to remove such a massive portion of a young individual's stomach when the patient's history indicates that his ulcer has been very acute. With the knowledge, however, which is generally expressed in the literature, that simple closure of a perforated ulcer results in the permanent relief of ulcer symptoms in not more than 25 per cent of the perforated cases, due credence must be given to the theory that many perforated ulcers are intractable ulcers.[9, 15, 20, 26, 27] The fact that from 25 to 30 per cent of the perforations having

simple closure will later require definitive surgery because of the persistency of the ulcer symptoms, is an added justification for the employment of primary definitive resection.

It is well that we should determine what type of surgical treatment is most effective in elective cases coming to surgery. We believe that the majority of surgeons believes that whereas subtotal gastrectomy is definitely a mutilating procedure, it is the most effective and rational surgical procedure which we have today for the treatment of peptic ulcer and its complications. We are presenting a comparative review of the progress of our patients having had elective gastrectomies as contrasted with the progress of our gastrectomies for perforations. Our studies would indicate that the same good results follow gastrectomies for perforations as is seen in the postoperative study of cases done electively. The complications observed in this comparative study of elective and perforated gastrectomies would indicate that the perforated cases do quite as well as do the elective cases. It is also observed that relatively the same percentage of patients are completely relieved of their symptoms in the two groups. This finding, in our judgement, repudiates the criticism often stated that gastrectomies done for perforations are not sufficient in scope as to the removal of adequate stomach. There are no unusual operative difficulties encountered in resecting perforated gastric or duodenal ulcers. Since most of these ulcers occur on the anterior wall of the stomach or duodenum, there is little likelihood of any fixation to the pancreas or adjacent structures. We think that actually a resection is technically less difficult in the perforated cases than is a resection in elective cases, because in many of the elective cases there will be penetration into the adjacent structures, increasing the difficulty of surgery. The resection of a perforated ulcer need not be in any manner a hurried procedure or a procedure which should be limited to a few dexterous gastric surgeons. The fact that our residents, with the usual supervision, have done these cases satisfactorily would seem to establish the fact that the operation is feasible in the hands of surgeons familiar with this operative effort. Certainly we do not think that a gastric resection under any circumstances should be done by the surgeon who has not had adequate experience with the technical problems involved.

OTHER METHODS OF TREATMENT

Our experience with the gastric suction method of treatment of perforated ulcers has been so extremely limited as to prohibit our expressing any *positive* opinion as to its efficacy. We have employed the suction treatment only in those desperate and moribund cases which were seen late and in which surgery would be obviously inadvisable.

Turner in 1952[26] suggested that it might be proper to treat perforated ulcers by simple closure, with the further practice of doing a subtotal resection on these people before they left the hospital. He was appalled at the high incidence of recurrence from simple closures. The general reports of favorable results from resections for perforated ulcers since the time of Turner's report would seem to now justify a primary definitive resection.

SUMMARY

An analysis is presented of all cases of acute gastroduodenal perforations occurring under our direct supervision since 1947. An additional smaller group of cases done by our exresidents in 1947 and 1948 is included as to mortality. A gradual change in our individual views of the treatment of this problem is manifested by the percentage of resections done in the first 3 years—52 per cent, as contrasted with our present practice of resecting more than 90 per cent of our perforated cases.

It is significant that during this course of our individual change in policy as to treatment, there has been no increased mortality in the cases treated in either group.

Evaluations of the mortality and morbidity rates among the groups treated by simple closure and those treated by gastrectomy indicate decisively that gastrectomy done as a definitive procedure is not unduly hazardous.

The conclusions drawn from this study suggest that gastrectomy may be employed with a sufficiently low mortality and morbidity as to justify its primary employment in gastroduodenal perforations. Particularly is this true when one remembers that 85 to 90 per cent of the patients having subtotal gastrectomy for either perforated or elective ulcers will be relieved of their symptoms by this operative procedure, as contrasted with the 70 to 75 per cent of ulcer persistency in patients having a simple closure. From 25 to 30 per cent of simple closures will have persistent and exaggerated ulcer symptoms ultimately justifying further definitive surgery.

A comparative analysis is made as to the mortality, morbidity and ultimate relief of symptoms in resections done electively and resections done for perforated gastroduodenal ulcers.

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Addendum: Since the preparation of this paper, two additional resections have been done by our own staff without mortality.

REFERENCES

1. Auchincloss, H., Jr.: Immediate subtotal gastrectomy for acute perforated peptic ulcer, Ann. Surg. *135:* 134 (Jan.) 1952.
2. Beahrs, O. H., Duncan, D. K., and Vadheim, L. A.: Emergency surgical treatment of perforated gastric and duodenal ulcers, Surg., Gynec. & Obst. *96:* 637 (June) 1953.
3. Bisgard, J. D.: Gastric resection for certain acute perforated lesions of stomach and duodenum with diffuse soiling of peritoneal cavity, Surgery *17:* 498 (April) 1945.
4. Brockman, H. L., Cooley, D. A., and DeBakey, M. E.: Acute gastroduodenal perforation; analysis of 44 cases treated by immediate gastrectomy, Am. Surgeon *19:* 182 (Feb.) 1953.
5. Burbank, C. B., and Roe, B. B.: Recent experiences with acute perforations of peptic ulcers at Massachusetts General Hospital, New England J. Med. *247:* 424 (Sept. 18) 1952.
6. Carayannopoulos, G., and Christopoulos, C.: Gastric resection as treatment of perforated gastroduodenal ulcer, Surgery *32:* 784 (Nov.) 1952.
7. Cooley, D. A., Jordan, G., Brockman, H. L., and DeBakey, M. E.: Gastrectomy in acute gastroduodenal perforation, Ann. Surg. *141:* 840 (June) 1955.
8. DeBakey, M. E.: Acute perforated gastroduodenal ulceration, Surgery *8:* 852 (Nov.) and 1028 (Dec.) 1940.
9. —— and Odom, C. B.: Significant factors in prognosis and mortality of perforated peptic ulcer, South. Surgeon *9:* 425 (June) 1940.

10. Emmett, J. M., and Owen, E. T.: Gastrectomy as treatment for perforated peptic ulcers, Ann. Surg. *138:* 320 (Sept.) 1953.
11. Graves, G. M.: Perforated peptic ulcer in German clinics, Ann. Surg. *98:* 197 (Aug.) 1933.
12. Hamilton, E. C., and Carlson, R. L.: Surgical treatment of perforated ulcer; analysis of surgical therapy at Thayer Veterans Administration from July 1, 1946 to June 30, 1952, Gastroenterology *26:* 734 (May) 1954.
13. Judin, S. S.: Partial gastrectomies in acute perforated peptic ulcers, Surg., Gynec. & Obst. *64:* 63 (Jan.) 1937.
14. ——: Etude sur les ulceres gastriques et duodenaux perfores, J. Internat. d. Chir. *4:* 219, 1939.
15. Kingsbury, H. A., and Peacock, E. E., Jr.: Acute perforation of peptic ulcer, Surg., Gynec. & Obst. *92:* 717 (June) 1951.
16. Lassen, H. K.: Treatment of perforated peptic ulcer, A. M. A. Arch. Surg. *65:* 673 (Nov.) 1952.
17. Milstein, B. B.: Late results of partial gastrectomy, Ann. Surg. *133:* 1 (Jan.) 1951.
18. Moore, F. B., and others: Effect of definitive surgery on duodenal ulcer disease, Ann. Surg. *132:* 652 (Oct.) 1950.
19. Moore, H. G., Jr., Harkins, H. N., and Merendino, K. A.: Collective review; treatment of perforated peptic ulcer by primary gastric resection, Internat. Abstr. Surg. *98:* 105, 1954.
20. Moore, S. W., and Hendricks, R.: Late results following perforated peptic ulcer, Surgery *23:* 442 (March) 1948.
21. Palumbo, L. T., and Rugtiv, G. M.: Results of operative treatment of acute perforated peptic ulcer, Surgery *34:* 635 (Oct.) 1953.
22. Rauch, R. F.: Evaluation of gastric resection for peptic ulcer, Surgery *32:* 638 (Oct.) 1952.
23. Robertson, H. T., and Akers, D. R.: Surgical treatment of perforated peptic ulcer, Am. Surgeon *20:* 190 (Feb.) 1954.
24. Strauss, A.: Primary gastric resection for perforated gastroduodenal ulcers, Ann. Surg. *120:* 60 (July) 1944.
25. Timpone, P. J., and Gross, L.: Emergency gastrectomy in surgical treatment of perforated peptic ulcer, Rev. Gastroenterol. *17:* 1138 (Dec.) 1950.
26. Turner, F. P.: Acute perforations of stomach, duodenum and jejunum, Surg., Gynec. & Obst. *92:* 281 (March) 1951.
27. Werbel, E. W., Kozoll, D. D., and Meyer, K. A.: Surgical sequelae following recovery from a perforated peptic ulcer, S. Clin. North America *27:* 93 (Feb.) 1947.

THE PRESENT STATUS OF THE TREATMENT FOR MALIGNANCY OF THE STOMACH

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One must be concerned with the type of malignant tumor with which he is dealing when applying therapy to these lesions in the stomach. Carcinoma, lymphoma and leiomyosarcoma are the prevailing types in that order of frequency. Prognosis varies according to the type and is probably best in lymphoma, second best in leiomyosarcoma and the poorest in carcinoma. Many attempts have been made to classifiy prognosis according to the cell type in carcinoma of the stomach, but it appears now that such prophecies cannot be held with high regard. But it is important to know that lymphoma, even the very extensive ones, can be treated with fair success if indeed its presence in the stomach is proved.

There are certain facts about malignancy of the stomach that we must know.

I. In carcinoma and leiomyosarcoma, surgery has proved to be the only therapy which will benefit the patient. Lymphoma is best treated by a combination of radiation and surgery. But the point remains—operation must be done to establish the identity, location and extent of the lesion and no chance for gain can be obtained without exploration.

II. Diagnostic mechanisms include history, physical examination, routine laboratory studies plus gastric analysis, x-ray studies, gastroscopy and cytologic examination. Gastroscopy in my experience has failed to diagnose a single case when the other measures failed to do so. We have had no experience with cytologic examination, but some hope for earlier diagnosis by this method is presently being entertained. An occasional case deserves exploration if the history is strongly suggestive in the face of other negative findings. This decision obviously must be made with extreme caution.

III. *Size of Tumor:* Formerly a large palpable mass was regarded to be a contraindication for operation. This is entirely false unless the large tumor by needle biopsy can be shown to invade the liver in a metastasizing manner. Some of the best results are obtained when the large tumor, present for a long period of time, does not show definite lymph node metastasis. Perhaps this is what Crile[1] means when he speaks of host resistance to the invasion of the tumor and in that way the prognosis is bettered. Many will prove to be inoperable, but if so, what can possibly be lost by looking? We have repeatedly and successfully removed gastric malignancies when the entire staff believed that no help was available.

IV. *Mobility:* Usually this is a favorable sign, but do not refuse laparotomy

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on account of nonmobility. Many times inflammation or retroperitoneal attachments near the pylorus or the rib margin in the upper lesions will induce immobility. The threat then is overcome when the lesion is finally freed at operation.

V. Extensive involvement by x-ray must not in itself contraindicate. It is suggestive of course, but again we have many times successfully resected a lesion which, according to x-ray, was hopeless (fig. 7).

VI. Distant metastases in locations such as the liver, lung, cervical lymph nodes, bone or carcinomatous peritonei or their various combinations are contraindicative with the exception of one, namely, the possibility of a solitary metastatic nodule in the liver. If this is believed to be the case, exploration is indicated. One must remember that the malignant lesion may be lymphoma and that inguinal, cervical and axillary lymph node involvement, with or without splenomegaly, may not necessarily contraindicate operation.

VII. The point is finally this: If the lesion is believed to be a malignant one in the stomach after careful, sensible appraisal, along with the studies referred to above, and real objective metastatic or extensive findings are not evident, then explore, because it is the patient's only chance for cure, longevity or short palliative relief.

Also, in spite of poor results to the contrary, one must know that there have been apparent cures after surgery and no cures (except one patient in Everson and Cole's relics[2]) unless resection has been performed. I can cite the instance of an Army Colonel who is alive and well 11 years after resection of a prepyloric carcinoma, a housewife living and well in 1956 who was resected for a large leiomyosarcoma in 1939, an actress who is living and well today nearly 20 years from her operation for pyloric carcinoma, and an old lady whose large mobile carcinoma was removed at the age of 84 and who was disgruntled at 94 because all of her family had predeceased her! These are a few perhaps of many who passed away earlier, but is it not a worthwhile venture when no other course is available?

At operation one is confronted first with establishing a diagnosis. If the lesion is a resectable one, it matters not which one of these types it may be. If not resectable for cure, then it is of paramount importance to establish the presence or absence of lymphoma, because partial resection in lymphoma can be very helpful, along with radiation. The unpardonable sin is not to take a specimen for biopsy even if the spread and metastases are copious and hopeless. An occasional rare occurrence of pancreatitis, tuberculous peritonitis, lymphoma, periarteritis nodosa and pseudomucinous peritonei may be the lesion instead of the hopeless carcinoma for which therapy may favorably alter the prognosis. Furthermore, if the patient is returned to the ward or home to die, it is comforting not to "sweat out" the possibility of error.

The next step is to decide the course of action which in our clinic is divided into four groups:

1. Subtotal radical gastric resection.
2. Total gastric resection.
3. Palliative gastroenterostomy or feeding jejunostomy.

4. Radical upper resection with esophagogastrotomy.

1. The majority of the patients will in our opinion be best treated by subtotal radical gastric resection, because most of the so-called operable cases are located in or near the pylorus and do not require the inclusion of the cardia or fundus (fig. 1). It has not been observed, as contemplated many years ago, that total gastric resection can yield better results unless the extensive procedure is required actually to permit a decent margin for a good cancer operation. If the lesion infiltrates the area of the fundus or cardiac end of the stomach, the total resection is done; but if not, the lesser procedure is done. We do not believe, for example, that a small lesion in the pylorus with involved lymph nodes at the cardia, particularly as it approaches the esophagus, will fare better with a total resection than with a subtotal, because extensive lymph node involvement, especially with distant lymph nodes, has not been cured with any degree of success by any operation, extensive or otherwise. But resection of the tumor with a margin in the organ will enhance the chances for reliable palliation for many months, sometimes a few years.

One must point out that the removal of the omentum and wide removal of the gastrohepatic peritoneum must better the situation, because the regional lymphatics are located in these easily removable structures. Splenectomy accompanies the subtotal resection if for any reason the splenic pedicle or adjacent stomach tissue is questionably involved. Therefore the procedure, subtotal though it may be, must vary according to the location, size and extension. The surgeon must alter his pattern of maneuvering to meet the circumstances at hand. Billroth I reconstruction is occasionally employed, but more often the Hoffmeister procedure is the anastomosing medium.

2. If the lesion involves the stomach to the extent that removal of the stomach is necessary to invoke the safe marginal area, then total gastric resection

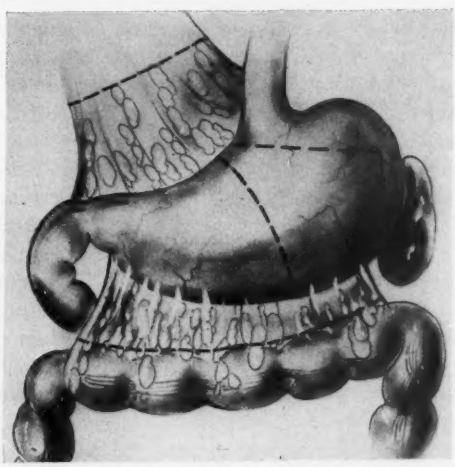

FIG. 1. Subtotal resection

is chosen (fig. 2). The operation requires complete removal of the omentum, stomach, the spleen, parts of the duodenum and esophagus and radical removal of the gastrohepatic peritoneum. As Zinninger and associates[9] pointed out, the neoplasm can extend into the esophagus and duodenum and margins at these ends of the resected material must be carefully established. In an occasional favorable case, duodenal resection may require removal of the second portion of the duodenum, which necessitates transplantation of the common and pancreatic ducts. Better gastrointestinal function can be had if some of the stomach remains, even if only a small segment.

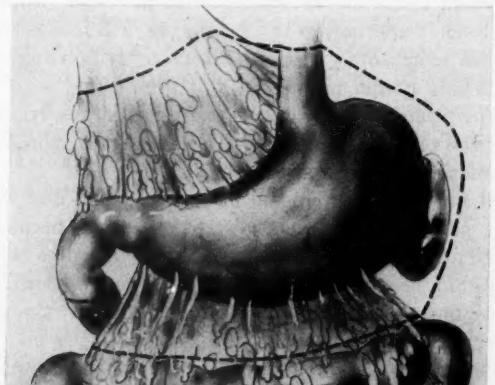

FIG. 2. Total resection

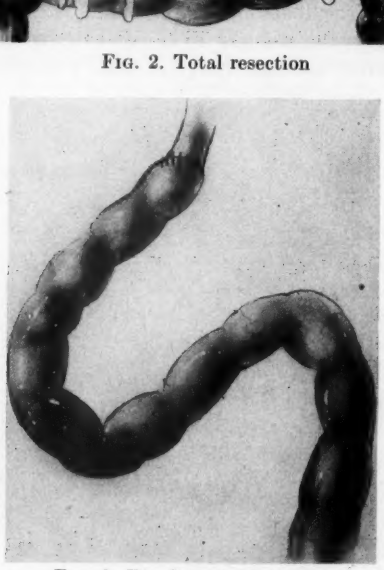

FIG. 3. Esophagoduodenostomy

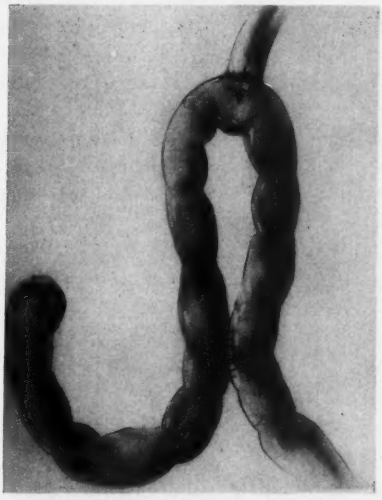

FIG. 4. End to side esophagojejunostomy

We use a slightly different approach to the total resection. First, the greater omentum is cut away from the transverse colon, the duodenum is transected and the stump closed if that is desired, the gastrohepatic ligament is dissected high under the liver, the esophagus is freed and cut across at the desired level and splenectomy is done as the last resecting act. Often the tail of the pancreas is removed along with the bloc excision. We have used three types of anastomoses, namely, esophagoduodenostomy, esophagojejunostomy (end to side) and esophagojejunostomy en Roux Y. Esophagoduodenostomy (fig. 3) is the simplest of these, cannot always be used, but is often followed by distressing bile regurgitation, weight loss, malnutrition, inanition and peptic esophagitis. The end to side esophagojejunostomy (fig. 4) did not function as satisfactorily as the end to end Roux Y procedure. In our hands the Roux Y anastomosis (fig. 5) is highly satisfactory, is accompanied with less complications than the other two procedures and functions well. Drainage is established by placement of a cigarette drain on either side of the anastomosis. This is believed to be an extremely important action. It establishes a way to avoid fatality if a leak occurs, prevents fluid collection around the line of anastomosis (which may delay healing) and also provides proper exteriorization for pancreatic juice if that organ has been intentionally or inadvertently traumatized. Of the 28 cases, there were 7 leaks and no real evidence of pancreatitis, and of course no deaths due to pancreatic trauma.

3. Palliative gastroenterostomy has been a very unsatisfactory procedure in our hands. It most often is an anterior anastomosis which will function if the obstruction is nearly complete, but has yielded not much more than 3 months' palliative relief. The neoplasm soon invades the anastomosed area.

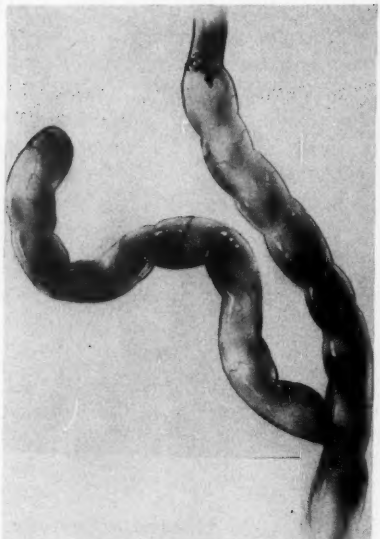

FIG. 5. Roux Y anastomosis esophagojejunostomy

Feeding jejunostomy prolongs life slightly and will comfort a few patients particularly those who want to add days to their lives at all cost. Many patients prefer not to use the tube feeding mechanism. Our choice of this procedure is largely dictated by the personality, philosophy and desires of the patient.

4. Resection of the cardiac end of the stomach and certain very extensive lesions in the pars media require inclusion of the lower third of the esophagus as well as any part or all of the stomach which must be removed to accomplish decent margins for cancer operation. Usually the spleen and tail of the pancreas are additionally removed and occasionally a left hepatic lobectomy or partial lobectomy accompany the procedure. The abdominothoracic incision is employed when high transection of the esophagus is desired. Whenever a high gastric lesion is suspected, the draping of the field is wide enough to permit the making of the thoracic part of the incision, usually in the eighth or ninth interspace. It is helpful to make the abdominal incision first, explore the lesion by that route and if the lesion is found to be inoperable, the incision is closed without opening the chest which probably saves the dying patient some postoperative distress, shortens the operation and saves valuable time. Inoperability must be established with great care and genuine conscientiousness, sincerity and without great haste. Often the lesion appears to be hopeless, but further probing and inspection reveals a better situation than the first glimpse suggested. It must be admitted that in the borderline operable case, the skill, integrity, patience, endurance and human interest of the surgeon count heavily in the patient's favor. Little can be accomplished in writing about this because the subject is not a

tangible one but nevertheless real. There are many documented instances when a more skillful and experienced surgeon has performed one of the resective operations, when exploration in less skillful hands denoted inoperability. Foolishly futile operations simply on the grounds that the patient is a cancer victim must be condemned.

A word must be said to re-emphasize the problem of lymphoma. It is our custom to resect if possible, regardless of extensive lymph node involvement, accurately locate remaining lymphoma in nodes or other tissue and promptly start x-ray therapy even before the stitches are removed or the wound has healed. Valuable time may be lost in waiting for the radiation; in fact, the neoplasm may spread while so doing. There has been no reason to regret the early use of x-ray in any case. In one instance, the plan was reversed. A large upper lesion was explored and the lymphomatous nature established, but the lesion was too large (fig. 6) and the extension too great for safe resection and anastomosis. The abdomen was closed, and x-ray therapy administered with some but not complete regression of the growth. Two months after cessation of the x-ray therapy, it was possible to perform total gastric resection without using the thoracic part of the incision. Disease was still present in the places observed during the first operation, but the size and extent had greatly diminished. The patient enjoyed an uneventful recovery and now, 8½ months after operation,

FIG. 6. X-ray denotes mammoth lymphomatous lesion which could not be successfully removed at first exploration. After x-ray therapy, total gastric resection was done with comparative ease at the second operation.

FIG. 7. Shows a resectable lesion in spite of extensive involvement shown on x-ray. Partial hepatectomy accompanied the total gastric resection.

appears well having returned to his normal work. Radiation therapy is given by a million volt machine which of course reduces the radiation damage in the abdominal wall. The results are not so good when the inoperable lesion is treated by radiation alone, but sensitivities of lymphoma vary considerably and even the most vicious and extensive lesions may respond surprisingly well to radiation therapy.

But this response to radiation is not favorably experienced when the lesion is carcinoma or leiomyosarcoma. We have employed x-ray therapy and nitrogen mustard therapy without benefit to a single case. Colloidal gold therapy may be beneficial, but our small experience has indeed been discouraging. It is to be hoped that some of the more modern chemical agents now in process of testing may prove to be helpful adjuncts and ultimately be successful to the point of eventual and permanent cure.

Results: Time and space will not permit extensive elaboration or presentation of confusing statistics. This paper does not portend to analyze the results with great detail, because it is intended to discuss the present approach to the problem of therapy.

Nevertheless, one must mention that subtotal gastrectomy is attended with the low mortality rate of 2 per cent and morbidity is reduced to a workable

minimum. Morbidity scores only when associated conditions such as heart, lung and kidney are present and significantly involved. The modern technician should not experience great difficulty and his complications should be low. However, there is an occasional technical accident when the procedure finally proves to be much more formidable than planned or mistakenly the lesions invaded tissues that threaten life if removal is attempted. Transplantation of the common and pancreatic ducts for instance, will certainly increase the mortality and morbidity rates and these structures must properly be sacrificed occasionally if the cancer is to be correctly attacked.

Total gastric resection for malignancy in our hands carries a mortality rate of 3.6 per cent. Morbidity, however, has been significantly elevated, particularly in our earlier experiences when perforation of the suture line occurred in seven cases.[7] When this unfortunate event occurred, we found that placing the patient on a Stryker frame in the prone position, which by gravity provided perfect drainage, probably enabled us to salvage many patients who otherwise would have died, and we believe that our low mortality rate is due to the use of this frame. Needless to state, blood replacement, electrolytic balance, antibiotic coverage and food intake are necessary for good results, but these items are needed for all major surgery and are therefore not slotted parts of gastric surgery. Pneumonia, atelectasis, empyema and lung abscess are complications usually secondary to the subdiaphragmatic infection. Fortunately, evisceration has not been observed in a single instance. This complication is an avoidable one and, if seen, directly relates to the lack of skill on the part of the surgeon and his team.

Therefore, mortality and morbidity are greater in the total gastrectomized patient than in the subtotal gastrectomized patient.

Function: Physiologic changes occur after subtotal as well as total gastric resection. The main disturbances concern weight loss, diarrhea, failure of digestion of fats and nitrogen, rapid absorption of carbohydrates, anemia usually of the hypochromic type, potassium deficiency and probably defects in other chemicals now unknown, and the expected weakness, lack of pep, etc., which would accompany these physiologic changes.

Because of these deleterious findings surgeons have tried to reform a pouch particularly in the case of total gastric resection, using colon as described by Lee[3] or jejunum as used by Beal and associates,[4] interposing these segments between the esophagus and the duodenum. Those who have used these pouches claim that there is a diminution of the physiologic defects described above and according to Beal[4] almost disappearance of them. An excellent paper by Nakayama[6] strongly advises the use of a stomach substitute and an equally excellent one by Moreno[5] claims that a conventional jejunal pouch is very satisfactory.

While we have experienced these defects in some patients, particularly when we used esophagoduodenostomy or esophagojejunostomy by the U method, we now have trouble but not too serious trouble since we have been using esophagojejunostomy en Roux Y and therefore see no reason to add the lengthy and certainly more dangerous time-consuming, pouchmaking procedures. Our func-

tional results are simply not that bad, and when present can be favorably bettered by some of the following procedures:

Dumping Syndrome: Dietary management which mainly means more bulky food, little or no liquid sweets at mealtime and accessory feedings. There are several instances of no significant dumping in the total gastrectomized group!

Diarrhea: Bile salts and Pancreatin as recently advocated by Shingleton and his group.[8]

Anemia: Administration of all vitamins, particularly vitamin B_{12} and iron therapy. Hydrochloric acid is employed by some, but has been very disappointing in our hands.

Potassium deficiency is overcome by the administration of potassium by mouth. This proved to be of great importance in 2 of our patients when large doses were necessary to maintain a proper potassium level. One patient died on the night of readmission for check on account of low potassium, 3½ years after total gastric resection. The postmortem examination failed to reveal evidence of carcinoma anywhere in the patient's body. His condition other than the potassium deficiency was good.

These simple postoperative aids have added greatly to our patients' comfort and safety.

It would be interesting to relate the degree of these same findings in the subtotal gastrectomized patients, but for brevity's sake let us state that the deficiencies are present but not in a significant degree. We know that a small cuff of remaining stomach seems to function better than the total removal. Actually, the number of dumpers, diarrheas, anemia, etc., in the subtotal group is so low that it is a small price to pay for longevity, cure or palliation. There seems to be less trouble when the subtotal resection is performed for malignant lesion than for ulcer.

Thirty-eight subtotal gastric resections (table I) have been performed with no operative mortality, with 15 subsequent deaths, 16 patients now living and 7 lost to follow-up. However, only 4 survived 5 years or longer.

Twenty-eight total gastric resections have been performed with a mortality rate of 3.6 per cent, with 18 subsequent deaths, with 9 patients now living and 3

TABLE I

Gastrectomy

Type of Tumor	No. Cases	Subtotal	Total	Living	Dead	5-yr. Survival
Carcinoma	55	31	24	17	31	4
Lymphosarcoma	9	5	4	6	3	3
Liposarcoma	1	1	0	1	0	0
Sarcoma	1	1	0	1	0	0
Total	66*	38	28	25	34	7

* 7 patients lost to followup.

patients who have survived 5 years or more. Obviously, the 5 year survival rate will be low if only 10 years' experience is reported, as is the case here.

One need not be too alarmed about the failure to cure, although of course cure is preferable. Lacking that, however, we can be encouraged by a Negro patient whose carcinoma perforated, was closed, malignancy proved by biopsy and total gastric resection performed 1 month after closure. He left the hospital 3 weeks after the resection, ate normally of the food provided for the family, carried a weight of 10 pounds less than the preoperative normal weight and returned at 5½ years with negative findings except a mass of enlarged left supraclavicular lymph nodes which are certainly metastases. At 6 years these lymph nodes were removed from the neck and he returned to the hospital to die 1 year and 4 months later—he had gained a total of 7 years and 4 months of almost normal living with no dumping, diarrhea, anemia or hypokaliemia and worked until the last year! The question arises—could he possibly have enjoyed this without the operations? If so, our operative therapy for all carcinoma has been useless, wasteful, destructive, unnecessary and dangerous.

SUMMARY

Some of the present day concepts of therapy for gastric malignancy are discussed.

The importance of establishing the histologic nature of the lesion is mentioned in relation to therapy particularly in the case of lymphoma, even though the situation may look hopeless.

Subtotal and total resection produce longevity, at least temporary cures and palliative relief which cannot be afforded without this therapy.

Mortality and morbidity in the total group, higher than in the subtotal group, are diminishing.

The individual can only gain by surgical therapy in carcinoma and leiomyosarcoma and by a combination of radiation and surgery when lymphoma is the lesion.

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REFERENCES

1. Crile, G. Jr.: Cancer and Common Sense, New York 17, N. Y., Viking Press, 1955.
2. Everson, T. C., and Cole, W. H.: Spontaneous regression of cancer; preliminary report, Ann. Surg. *144:* 366 (Sept.) 1956.
3. Lee, C. M., Jr.: Transposition of colon segment as gastric reservoir after total gastrectomy, Surg., Gynec. & Obst. *92:* 456 (April) 1951.
4. Longmire, W. P., Jr., and Beal, J. M.: Construction of substitute gastric reservoir following total gastrectomy, Ann. Surg. *135:* 637 (May) 1952.
5. Moreno, A. H.: Studies on nutritional and other disturbances following operations for cancer of stomach with particular reference to use of jejunal pouch as substitute gastric reservoir, Ann. Surg. *144:* 779 (Nov.) 1956.
6. Nakayama, K.: Evaluation of various operative methods for total gastrectomy, Surgery *40:* 488 (Sept.) 1956.
7. Sensenig, D. M., and Campbell, R. E.: Total gastrectomy with reference to chronic hypokaliemia, Ann. Surg. *145:* 81 (Jan.) 1957.
8. Shingleton, W. W., and associates: Paper presented at meeting of Society of University Surgeons, Columbus, Ohio (Feb. 8) 1957 (in press).
9. Zinninger, M. M., and Collins, W. T.: Extension of carcinoma of stomach into duodenum and esophagus, Ann. Surg. *130:* 557 (Sept.) 1949.

THE SURGICAL IMPLANTATION OF TUMORS*

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The medical profession has known for years the danger of implantation of tumor cells during operations for malignancies. Halsted, Meyer, and Rodman outlined technics for performing the radical mastectomy for breast carcinoma, planning the operation so that cancer filled tissue is never cut across, since soiling of the wound with cancer cells might result in recurrence. Extreme caution is still exercised by surgeons today, following the above precepts in breast cancer; however, it is appalling to find little attention paid to these principles when the cancer is located elsewhere. There is increasing evidence that inadequate operations for cancer tend to spread the disease rather than deter its growth. Surgical manipulation may produce showers of tumor emboli through the venous system producing widespread metastases. Lack of "en bloc" excision, cutting into the tumor, and rough handling, lead to contamination of gloves and instruments with resulting wound implants.

The needle biopsy, on the surface, seems to be a very simple procedure without much danger. Recently, Crile[3] has reported disastrous results when such a procedure was carried out in a case of papillary carcinoma of the thyroid.

The following brief case presentation will bring out some of the points in question:

CASE REPORTS

Case 1. Mrs. E. F. G. was first seen on July 27, 1955 complaining of swelling in the left side of her abdomen. The enlargement of the abdomen had been rapid and was producing pressure symptoms. Pelvic examination revealed a large tumor mass, nodular, irregular, and filling the entire pelvis. At operation on July 28 a bilateral papillary cystic adenocarcinoma of the ovaries with peritoneal spread was encountered. Bilateral salpingo-oophorectomy was performed and followed by Cobalt-60 teletherapy.

On April 25, 1956, this patient was readmitted with ascites due to peritoneal metastases and an abdominal paracentesis was performed removing 3 liters of fluid. The patient returned on June 18 for a second paracentesis, and metastatic tumor nodules were noted at the site of the previous tap (fig. 1). The patient was tapped repeatedly and died on July 31, 1956. Postmortem examination was obtained.

This case reveals that needle biopsy can lead to spread along the needle tract. Free tumor cells from peritoneal fluid grew in the area of traumatized tissue (figs. 2, and 3).

Case 2. Mr. A. R. C. This 48 year old white man was first seen on Aug. 3, 1947 complaining of pain in the epigastrium, fainting and tarry stools of 2 days duration. There was a history of indigestion, gas, bloating, and cramps for 15 years. The physical examination was essen-

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FIG. 1. Case 1. Photograph showing tumor implants in sites of paracenteses

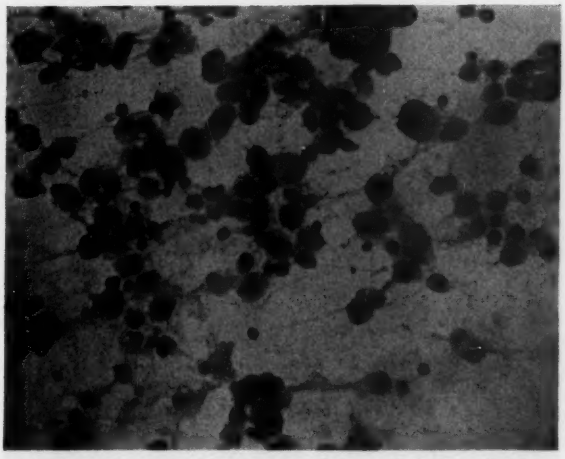

FIG. 2. Case 1. Photomicrograph by Papanicolaou technic showing tumor cells in free peritoneal fluid.

tially negative except for evident anemia. Roentgenograms revealed an annular neoplasm of the ascending colon. After bowel preparation with sulfasuxadine and restoration of blood volume a right hemicolectomy was performed with ileotransverse colostomy. The convalescence was uneventful (fig. 4).

The patient was followed in our tumor clinic with periodic roentgenologic studies of the colon. On Sept. 20, 1950 he returned complaining of cramps and recurrent dark stools. Roentgenograms revealed a recurrent lesion in the region of the previous ileotransverse colostomy. On September 23 the patient was re-explored and the ileotransverse colostomy was resected with a malignant recurrence at the anastomotic site (figs. 5, 6). Recovery was uneventful and he was followed in the tumor clinic.

FIG. 3. Case 1. Photomicrograph showing tumor cells in needle tract of previous paracentesis.

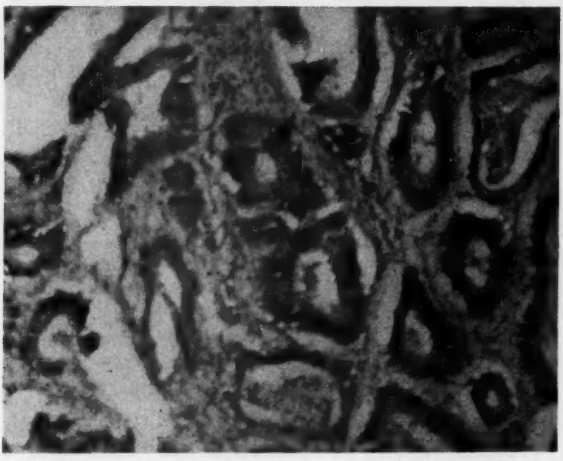

FIG. 4. Case 2. Photomicrograph of adenocarcinoma of cecum

On Feb. 2, 1952 the patient returned complaining of gas and increasing constipation. No masses were palpable either abdominally or rectally but barium enema revealed a neoplasm of the descending colon. The remainder of splenic flexure and descending colon was removed to the peritoneal reflection with ileoproctosigmoidostomy. He has remained well since that time.

This case shows that tumor cells may be free in the bowel lumen and become implanted at the site of anastomosis, even though there may have been a large segment of bowel removed. Wide resections and gentleness are necessary to prevent this unfortunate complication.

FIG. 5. Case 2. Gross specimen showing recurrence at the site of anastomosis

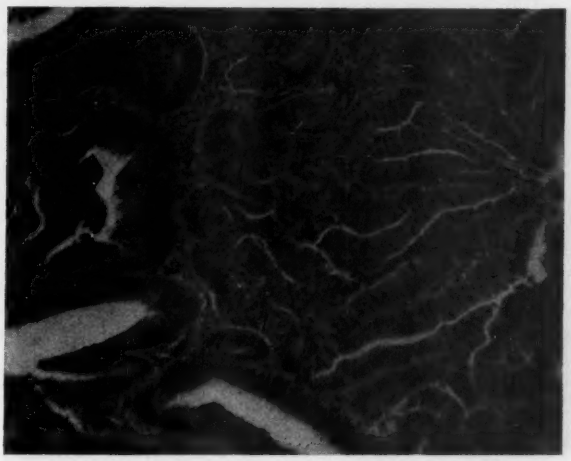

FIG. 6. Case 2. Photomicrograph showing adenocarcinoma at site of anastomosis

Case 3. Mr. A. J. P. This 83 year old white man was first seen on Nov. 9, 1953 complaining of weakness of 4 to 5 months' duration. There had been a weight loss of about 18 pounds, some loss of appetite, gas, and dizziness, and increasing pallor.

Examination revealed a rather pale, agile, well developed white man, who did not appear to be his stated age. The physical examination revealed some voluntary rigidity in the epigastrium but no definite organs or masses were felt. The red cell count was 3,500,000 per cu. mm. with 5 Gm. of hemoglobin. The gastric analysis revealed only 5° of free HCl on fasting, 30 minute, and 60 minute specimens. Roentgenograms revealed a "shelving" defect of the pyloric antrum with diagnosis of gastric neoplasm.

After restoration of blood volume by transfusion, the patient was explored on Nov. 18,

FIG. 7. Case 3. Photomicrograph of adenocarcinoma of stomach

FIG. 8. Case 3. Photograph showing mass in wound

1953. At operation a large lesion was encountered in the pyloric region of the stomach with involvement of pyloric nodes. An extensive resection was carried out (fig. 7).

The patient was followed in the tumor clinic. On Feb. 14, 1954 a nodule was noted in the wound at the upper portion. By March 30 this nodule was much enlarged and measured 10 by 8 by 6 cm. He was admitted and a biopsy was performed revealing metastatic adenocarcinoma of the abdominal wall (fig. 8). Following the biopsy, he was treated with Cobalt-60 teletherapy. On Aug. 18, 1954 he died and a postmortem examination was obtained revealing metastatic carcinoma to the upper abdominal nodes, liver, and common duct and implantation into the surgical scar on the abdomen without any direct extension (fig. 9).

This case reveals obvious contamination of gloves or instruments with resulting implants to the abdominal wounds.

FIG. 9. Case 3. Photomicrograph of tumor in abdominal wound

Case 4. Mr. M. C., a white man, aged 60, was first seen on Dec. 5, 1951 with a history of gastrointestinal disturbances of one year's duration consisting of nausea, gas, and occasional vomiting. About 24 hours prior to admission he developed crampy pain in the mid and lower abdomen with severe nausea and vomiting. The vomitus was of a fecal type. Examination revealed the abdomen to be distended, moderately tympanitic, and moderately tender throughout. A Miller-Abbott tube was passed and an upright film of the abdomen revealed several dilated loops of small bowel with fluid levels compatible with intestinal obstruction. The patient was referred to the surgical service on December 13. A barium enema revealed an obstructing lesion in the lower sigmoid colon. The Miller-Abbott tube was lying near the ileocecal valve. On December 14 a transverse loop colostomy was performed through a transverse incision above the umbilicus.

On Dec. 29, 1951 an extensive resection of the sigmoid and left colon was carried out. The pathologic examination of the resected specimen revealed an annular adenocarcinoma of sigmoid colon with local invasion and regional metastases (fig. 10).

On Jan. 14, 1952 the transverse loop colostomy was closed and he was discharged on January 24 in good condition.

He was followed regularly in the tumor clinic and on Nov. 8, 1956 returned with pain in the region of the transverse loop colostomy scar and soreness in the upper abdomen. Examination revealed a firm nodule in the region of the scar measuring 3 by 3 by 2 cm. which was somewhat tender. On November 19 an excisional biopsy was performed of the nodular lesion which revealed metastatic adenocarcinoma (fig. 11). The patient was given a course of Cobalt-60 teletherapy to this region. The course was completed on Dec. 29, 1956.

The lesson to be learned by this case is that the obstructive lesion with direct extension to peritoneum was palpated at the time of colostomy leading to contamination of gloves and wound implants.

There are several simple methods of preventing the spread of tumors by surgical methods.

The first is excisional biopsy as opposed to incisional biopsy, whenever possible, when this is needed for diagnosis. The surgical staff of our clinic routinely employ this procedure. In thyroid nodules, the nodule and a generous portion of normal tissue is removed; even total lobectomy may be performed. Frozen

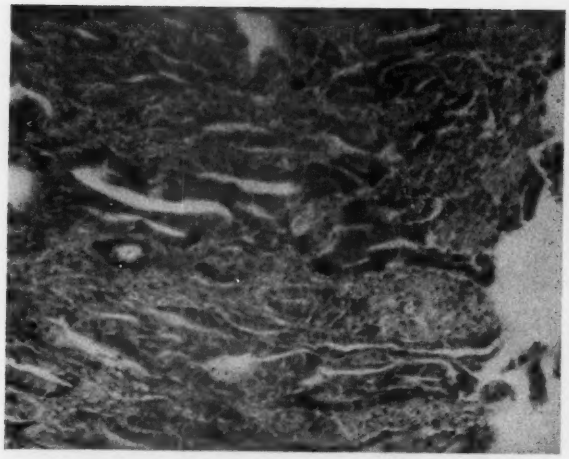

FIG. 10. Case 4. Photomicrograph showing adenocarcinoma of colon

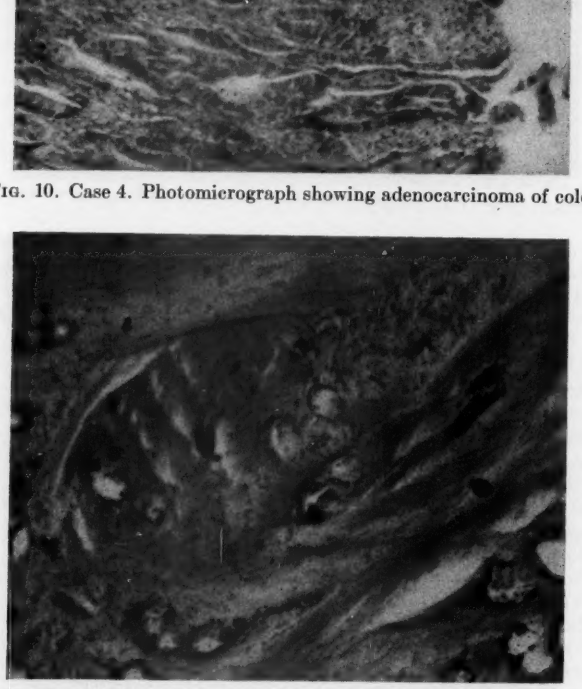

FIG. 11. Case 4. Photomicrograph of metastatic adenocarcinoma of wound

sections are performed if deemed necessary before closure of the wound so that more extensive surgery may be carried out if required.

The second is the use of an electrosurgical unit. In breast biopsies the high frequency knife is routinely employed. The tumor mass is completely excised. The electrosurgical unit lightly coagulates the wound edge as it cuts, and by this process, we believe inhibits the implantation of tumor cells since there is no raw wound surface. If malignancy is found in the frozen section, the wound is packed with a gauze strip saturated with buffered formaldehyde solution and closed with a running suture. The gloves and instruments used in taking the

biopsy are discarded, the field reprepared and draped, before proceeding with the radical operation. In superficial, ulcerated, skin lesions, such as basal cell carcinoma, in order to prevent wound contamination, the area is coagulated and later excised. By so doing the tumor cells on the surface are destroyed.

The third principle is gentleness. Gentleness in handling of tumors cannot be overemphasized. In 1913 Tyzzer[7] showed that simple massage of mouse cancer increased the incidence of pulmonary metastases from zero per cent in the controls, to 80 per cent in the massaged mice. Tyzzer warned surgeons about rough handling of cancer, saying, "The palpation of the mass in question in repeated physical examinations, the violent scrubbing often employed in preparing the field of operation is almost identical with that which I have employed for the experimental production of metastases. It would be an advantage to the patient if each questionable tumor could be regarded as a high explosive, the least manipulation of which should be absolutely avoided both prior to and during the operation."

Turnbull,[6] observed that specimens of blood drawn from the mesenteric veins of patients with cancer of the colon contain few, if any, tumor cells when the primary tumor is not manipulated but after manipulation the blood is showered with tumor cells in 30 per cent of the cases.

After colon resection, we have been able to demonstrate tumor cells in the lumen of the bowel by the use of smears and Papanicolaou stains some distance from the original tumors (fig. 12). When the tumor has spread to the serosal surface we have likewise demonstrated tumor cells by Papanicolaou technic.

It is, therefore, possible by squeezing of any cancer that systemic metastases may result from tumor emboli squeezed into the venous system.

The fourth principle is the covering of the lesions of the bowel with a moist

FIG. 12. Photomicrograph of tumor cells free in lumen of bowel by Papanicolaou stains.

pack or rubber dam when the spread has extended to the serosal surface to prevent contamination.

The fifth method is the early ligation of the major blood supply without undue manipulation of the tumor, thus cutting down on venous tumor emboli.

Pathologists have long called attention to the growth of cancer into veins within the tumor.[1, 2] This is especially true of the important tumors which produce widespread metastases such as the colon, rectum, breast, thyroid, and prostate. Fisher and Turnbull[5] in 1955 reported the finding of cancer cells in 32 per cent of the veins of specimens of carcinoma of the colon removed at operation at the Cleveland Clinic. Because of these venous emboli, Cruz, McDonald, and Cole[4] have recently advocated the use of chemotherapeutic agents to prevent tumor metastases. It was their opinion that the tumor cells would be vulnerable to destruction by chemicals while loose and floating before acquiring a vascular attachment. A course of nitrogen mustards was given, except in elderly and debilitated patients, beginning the day of operation. The conventional dose of .1 mg. per kilogram of body weight was given intraperitoneally at the time of celiotomy. A maximum daily dose of 6.5 mg. was given. A second dose was given the first postoperative day, and 2 additional doses were completed by the fifth postoperative day. This has been used too short a time for complete evaluation. This seems logical and our group is considering the use of nitrogen mustards for prevention of venous spread, and radioactive gold where there is a possibility of peritoneal contamination.

Last, a brief consideration of spread to the suture line in bowel carcinoma. Formerly, our group used the electrosurgical unit for sectioning of the bowel, whenever this could be employed without explosive hazards. It was thought that by coagulating the surface any tumor cells present could be eliminated. In recent years we have employed only a carbolized scalpel for this section. After the recurrence at the suture line in Case No. 2, and the finding of free tumor cells in lumen of the bowel some distance from the primary lesion in resected specimens, we have decided to resume the use of the electrosurgical unit in sectioning of the bowel.

SUMMARY

In summary, it is evident that we must always be cognizant of the fact that there is danger of implantation of tumor cells which may result in disaster. It is thought that these may be minimized by:

(1) Excisional biopsy whenver feasible.

(2) "En bloc" excision of all tumors.

(3) Gentleness in handling of tumors at operation thus minimizing venous tumor emboli.

(4) The covering of tumors on serosal surfaces to prevent glove and instrument contamination.

(5) The proper use of the electrosurgical unit in selected cases.

(6) The use of chemotherapeutic agents for destruction of tumor emboli.

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REFERENCES

1. Barringer, P. L., Dockerty, M. B., Waugh, J. M., and Bargen, J. A.: Carcinoma of large intestine; new approach to venous spread, Surg., Gynec. & Obst. *98:* 62 (Jan.) 1954.
2. Brown, C. E., and Warren, S.: Visceral metastasis from rectal carcinoma, Surg., Gynec. & Obst. *66:* 611 (March) 1938.
3. Crile, G., Jr.: Danger of surgical dissemination of papillary carcinoma of thyroid, Surg., Gynec. & Obst. *102:* 161 (Feb.) 1956.
4. Cruz, E. P., McDonald, G. O., and Cole, W. H.: Prophylactic treatment of cancer, Surgery *40:* 291 (Aug.) 1956.
5. Fisher, E. R., and Turnbull, R. B., Jr.: Cytologic demonstrations and significance of tumor cells in mesenteric venous blood in patients with colorectal carcinoma, Surg., Gynec. & Obst. *100:* 102 (Jan.) 1955.
6. Turnbull, R. B., Jr.: Personal communication.
7. Tyzzer, E. E.: Factors in production and growth of tumor metastases, J. Med. Res. *28:* 309 (July) 1913.

TRAUMATIC INJURIES OF THE LOWER URINARY TRACT

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Traumatic injuries of the urinary bladder, prostatic and membranous urethra, and of the penile urethra, result from perforation by bullets, shell fragments, spicules of bone, pointed objects, and unfortunately, urological instruments. Bladder perforation was found in 75 per cent of Fullerton's[2] 53 cases of buttock wounds and in 56 per cent of Michels'[7] 155 cases. Clarke and Leadbetter[1] stated that "in 70 per cent of the 315 bladder wounds on which data could be obtained, wounds of the small and large intestine, or of the rectum, were present". When the pelvis is fractured, rupture of the bladder must be considered until proved otherwise. Bladders do not rupture from overdistention alone but distention to some degree must be present for rupture from a blow to the lower abdomen. Rupture of the membranous urethra is rare in children, but quite common in adults with enlargement of the prostate gland. A blow, fracturing the symphysis pubis or the pubic and ischiatic rami will force the prostate dorsally while the membranous urethra is fixed by the pelvic diaphragm which results in shearing of the urethra at the prostatic apex. Wounds of the pendulous urethra are most frequently caused by urethral instrumentation, and 30 per cent according to Petkovic are open wounds.

I well remember my first urologic consultation in a case of traumatic injury. A 14 year old boy slid down a haystack, becoming impaled on the broken shaft of a pitch fork. This pointed handle passed through the left ischiorectal fossa. Someone had sawed off the protruding portion with the tines and brought the boy to the hospital without withdrawing the shaft. The boy was unconscious but someone had observed that he had urinated a few moments before the accident—a very happy observation. On examination, there was little, if any, costovertebral angle tenderness. The kidneys were not palpable. The abdomen was rigid. There was ecchymosis of the posterior half of the scrotum. This is common with perineal injury. It occurs following perineal prostatectomy. The bladder was not palpable nor percussible. There was no bleeding from the urethra. When injury to the bladder or urethra is suspected, the patient should not be encouraged to urinate. A no. 20 soft rubber catheter was passed through the urethra with ease and, to my amazement, 50 cc. of urine was obtained, grossly and microscopically free of blood. This fact, it seemed to me, ruled out urethral and bladder injury and also renal trauma. The only possible urologic injury could have been severance of a ureter. X-ray examination showed the tip of the fork handle in the upper abdomen. Laparotomy was performed by a general surgeon. This sharp pointed pitch fork handle had passed through the left ischiorectal fossa, entered the peritoneal cavity between the prostate and rectum, missed

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the sigmoid and its mesentery and the small bowel but perforated the transverse colon. The defect in the bowel was closed after evacuation of blood from the peritoneal cavity. Drainage of course was through the perineum after removal of the shaft. This patient recovered in 1929, without the aid of modern antibiotics.

After severe injury, the history is usually meager or of little aid. One must depend upon physical examination for a diagnosis. There is no single, reliable test. During my urologic residency, I was called to the accident room by one of the surgical internes to see an inebriated patient who had been hit by a streetcar. I observed no blood on the patient's underclothes nor at the urethral meatus. There was ecchymosis to the left of the symphysis pubis and abrasions over the eleventh and twelfth ribs near the spine. The abdominal wall was rigid. The kidneys were not palpable. The intern showed me 1200 cc. of smoky urine which he said he had obtained by catheterization. Therefore, he had concluded that the bladder was intact and that the patient probably had left renal injury, but he had not percussed a distended bladder before passing the catheter. In this case, I doubt if palpation or percussion of the bladder would have been accurate. A digital rectal examination, which was not done by the intern, would have ruled out serious rupture of the membranous urethra and I believe that bladder distention can be more accurately determined by this means than by abdominal palpation. In this case, further examination would have to be done to rule out rupture of the bladder. The patient could have been catheterized again, a known quantity of sterile saline solution injected, and the return measured, and if none, or a lesser quantity returned, the diagnosis of ruptured bladder would be probable. A cystogram could have been done to demostrate the extravasation of iodide. Cystoscopy was not considered feasible in a patient with an obviously fractured pelvis. Because laparotomy was indicated for serious internal hemorrhage, the aforementioned tests were not performed. The intern's catheter had passed through the bladder into the peritoneal cavity, through a 1½ inch tear in the bladder wall. Lynch[6] has reported a normal intravenous urographic study with normal excretory cystogram in a patient with intraperitoneal rupture of the bladder. The perforation was temporarily sealed off by a loop of intestine.

Although this paper is supposed to be limited to wounds of the lower urinary tract, I wish to present a case illustrative of the value of a good history in the case of injury. A 47 year old obstetrician had consulted me 2 years prior because of arterial hypertension. I advised intravenous urographic study which was not done. He called me at 9:00 a.m. on July 12, stating that he had right renal colic and that he could get to my office immediately. About a half hour later his wife called to say that her husband had fainted while en route, and she had returned him to Suburban Hospital. I talked to the intern who stated that the patient appeared to be in shock but that his blood pressure was 130/80. With his past history in mind, I concluded he could well be in shock and ordered supportive measures until I could drive to the hospital. Thirty minutes later his blood pressure was up to 150/90, and the patient felt quite well. The good doctor was inclined to minimize his symptoms but the wife supplied significant details. He

had been called at 3:00 a.m. for a delivery. He got out of bed, urinated, dressed, and went out. The wife filled in the information that he had fallen down the stairs.

"No, I only stumbled on the second from the bottom step".

What happened when you got to the hospital?

"I did the delivery, an easy one, and then felt very weak. I lay down in the lounge for a couple of hours and went home. Oh yes, I voided a tremendous quantity of urine as soon as I got to the hospital, I had forgotten I had voided before leaving the house and did not turn on the light to look at it".

A voided specimen of urine was half blood. Physical examination revealed nothing but a palpable right kidney and a questionable elevation of the right diaphragm. A scout film of the abdomen revealed a 20 cm. round, mass at the upper pole of the right kidney. Intravenous urographic study showed an upper renal mass with dislocation of the upper calyces. There was no evidence of extravasation of urine. Without the history, a correct diagnosis could not have been made. Obviously, the slight stumble on the stairs ruptured a large solitary cyst of the kidney into the renal pelvis. This accounted for the large voiding a few minutes after evacuation of the bladder. The cyst filled with blood brought on weakness during the night. The tear inside the kidney was tamponated, the blood pressure rose, to fall again with severe bleeding on his trip to my office. The wound again was tamponated but following the urographic study, bleeding again became severe and emergency renal surgery was necessary to save his life. Nephrectomy was quickly accomplished and with the aid of blood transfusions he made a good recovery. Incidentally, his arterial hypertension persists.

In cases of acute injury, the experienced urologist is rarely called immediately. We see the patient after a work-up by the intern or resident staff, and usually after the attending surgeon has seen the patient. I am not at all critical. I do believe, however, that the general surgeon and surgeons in training, should have the benefit of urologic experience. Urologic wounds are not incidental. They are as serious as fractures, bowel perforations, arterial injuries, and ruptured viscera. Gross or microscopic hematuria prompts a surgeon to request urologic consultation. I[4] was amazed, during World War II, at the complacency of surgeons caring for patients with urine draining from wounds. In the case of a soldier draining urine from the exit wound of a bullet through the pelvis, the bullet passed from the left thigh, through the obdurator foramen, perforating rectum and bladder, passing through the right sciatic notch and out the right thigh. It did not hit bone nor a major blood vessel. It caught the peroneal portion of the sciatic nerve. Laparotomy was performed, the bowel and bladder closed, adequate drainage was established, but no attention was paid to the persistent drainage of urine from the exit wound. This urine was not from the bladder but from the ureter which was partially severed. In another case, urine persistently drained from a ruptured bladder through a fistulous tract in the right femoral triangle in the case of a nurse who had sustained a fractured pelvis in a jeep accident. Inadequate drainage following repair of the ruptured bladder had allowed abscess formation with resultant fistula.

Cystostomy for diversion of urine, repair of the defect, and drainage for extravasation of urine, are necessary in the treatment of ruptured bladder.

The diagnosis of rupture of the membranous urethra should not be difficult, yet long delays are recorded in many cases before definitive surgery is undertaken. Lynch[6] reported a delay of several months in the case of a 10 year old boy. There were fractures of the femurs and of the pubis. A catheter had failed to pass. Cystostomy was performed. Apparently digital rectal examination was not done. The diagnosis of rupture of the membranous urethra was made after abscesses had formed and multiple perineal fistulas developed. The diagnosis of rupture of the membranous urethra can be readily made by palpation of a defect in the continuity of the urethra between the bulb and prostatic apex. Dislocation of the prostate is evidence of complete severance of the membranous urethra. The treatment, as in rupture of the bladder, consists of cystostomy for diversion of urine, drainage for extravasation, and repair of the urethral defect to insure continuity of the urethra. I do not believe placement of a catheter for traction on the prostate and alignment of the urethra is sufficient.

A 40 year old man was injured in July 1954, his pelvis crushed between a concrete laying machine and a wall. He suffered fractures of the acetabulum bilaterally and of the ramus of the pubis and ischium on the right side. This patient was in profound shock. There was abdominal wall rigidity. There was clotted blood at the urethral meatus. He had passed no urine. There was a deep rent in the perineum which opened the rectum anteriorly for 2 inches. The anal sphincter was split. A large blood clot was palpable through the perineal wound but no prostatic tissue could be felt. Sharp spicules of bone from the fractured pubic and ischiatic rami were palpable. A catheter passed through the urethra emerged in the perineal wound. After recovery from initial shock treated by transfusions, a suprapubic incision was made. Extravasated blood was evacuated. The bladder, with the prostate gland, was found high in the wound 4½ inches above the normal site. Because of the severely lacerated rectum, a left transverse colostomy was done. Urine was diverted by cystostomy and a Foley catheter was passed through the urethra, threaded through the prostatic urethra into the bladder for traction and as an urethral splint. Because of the patient's precarious condition, repair of the rectum and anastomosis of the urethra was not attempted. Three months later, repair of the urethra and rectum was undertaken by the urologic consultant. The suprapubic tube was removed for passage of sounds transvesically to meet sounds passed by way of the urethra. A 1 inch defect between the bulb and prostatic apex was noted. The rectum was repaired by longitudinal suture but it seemed impossible to bring the prostate and bladder into normal position. A no. 22 Foley catheter was left in-dwelling and the cystostomy tube was replaced. Shortly thereafter the suprapubic tube was removed and the sinus closed quickly. The urethral catheter was changed every 2 weeks for about 2 months, then after removal of the catheter the patient voided for 1 day and went into urinary retention. The catheter was replaced without difficulty but when it was removed the second time, the patient voided for 3 days and the catheter could not be reinserted. The cystostomy wound was opened. Calculi

were removed from the bladder, but only a filiform could be passed from the urethra to the bladder. The urethra was eventually dilated with La Forte sounds, but due to massive perineal scar formation, the urethra could not be kept open. Stone formation in the bladder and along the urethral filiform splint was a serious problem.

I saw this patient in consultation in March 1955, 8 months after injury. His general physical condition was poor because he could not eat. He was emotionally unstable and quite addicted to Demoral. There was slight renal tenderness bilaterally. The colostomy was functioning well. A linen thread passed from the suprapubic sinus tract from the end of the no. 22 urethral catheter. Urine drained from the sinus and from the anus, the catheter being obstructed by stone. The catheter had been replaced 3 days before. The perineum was badly scarred and the anus had constricted to no. 18 French circumference. X-ray examination showed the fractures well healed without osteomyelitis. The bladder was filled with stone and the urethral catheter was solid from incrustation. A cystogram showed the base of the bladder elevated 1½ inches above the superior border of the symphysis pubis.

Permanent drainage of the urine by transplantation of the ureters into an isolated cecal or ileal pouch was considered. However, a rectal repair as for rectal urethral fistula had to be done and I thought that approximation of the severed ends of the prostatic and bulbar urethra should be attempted in spite of the mass of intervening scar tissue. A racket shaped incision was made around the anal margin extending forward in the perineum. Some anal sphincter fibers were recognized and preserved. The rectum was dissected free for 6½ inches, a most difficult procedure because of scar. This brought the rectal fistulous opening outside the anus. A tremendous amount of scar tissue was then removed from the area between the bulb and prostatic apex behind the symphysis pubis. Previous experience with severe perineal wounds had convinced me that the external urethral sphincter is not necessary for urinary control when the bladder neck is intact. But the prostate and bladder could not be brought down from the perineal approach. The patient was taken out of lithotomy position and the suprapubic scar excised. The bladder was further opened and many stones removed. The prostate and lateral surfaces of the bladder were freed from the imbedding scar until approximation of the prostatic and bulbous urethra was accomplished by passing heavy silk sutures from the prostatic capsule through the perineum to be tied over buttons according to Leadbetter's report. A no. 24 red rubber catheter was sutured in place. The cystotomy tube was replaced and adequate drainage provided by suprapubic and perineal cigarette drains. The excess of rectum was removed, stay sutures were passed from the rectal wall to the lateral and posterior deep parts of the fascia of the pelvis, the mucus membrane of the rectum was fastened to the anal margin with interrupted silk sutures. The anal sphincter was repaired anteriorly and the wound in the perineum partially closed. Because Suby's solutions, acetic acid, and phosphoric acid irrigations had failed to prevent incrustation of the bladder and tubes from bacillus proteus infected urine, I decided to try something new. The urethral

catheter, therefore, was constantly irrigated with 0.8 per cent Mandelic acid solution. This solution is odorless, nonirritating, and prevented further incrustation in this patient. I used it in many patients with better results than I had had previously. The colostomy was closed by reanastomosis of the bowel 6 weeks after major repair. This patient had perfect urinary control. Sounds to no. 26 French have been passed with ease at 2 week intervals. Bowel habits are normal. The patient is doing part time work.

Wounds of the bulbous and pendulous urethra result in stricture formation, with or without abscess formation, and with or without fistula formation. When the involved area is less than 1½ inches in length, excision of the fistulous tract and of the scar in its entirety with exact reanastomosis of the ends of the urethra, is the operation of choice. This was accomplished in a patient who had developed abscesses, a diverticulum of the urethra, and an impassible stricture of the bulb. Excision with anastomosis of the urethra caused a 1½ inch shortening of the urethra but a very satisfactory result.

Traumatism of the urethra during transurethral resection of the prostate gland has created a very serious problem for the urologist. These internal traumatic strictures are of considerable length and resist dilation. They are too long to resect and internal urethrotomy is not very satisfactory. Gradual dilation by increasing the size of indwelling catheters with the use of Cortisone to decrease scar formation seems the method of choice.

SUMMARY AND CONCLUSIONS

The surgical history in severely injured patients is not always available but significant details may be of great value in diagnosis. A record of previous surgery on the kidney for ureteral pelvic juncture obstruction with nephropexy makes that kidney more vulnerable to injury. Force and type of injury, jackknifing, crushing of the pelvis, straddle injury, the type of piercing object or instrument are important. The history of voiding prior to and subsequent to injury, hematuria, and bleeding from the urethra, are significant. Concomitant injuries, such as fractures, particularly of the pelvis, perforating wounds, including the viscera, and chest, are frequently encountered. Rupture of the spleen or liver does not exclude rupture of the kidney on the ipso or contralateral side. I have seen a boy with a ruptured spleen and a ruptured bladder without renal injury.

In the physical examination, first look at the patient's underclothing for signs of blood or urine. Then examine for external signs of injury, abrasions, ecchymoses, hematomas, and blood at the urethral meatus. The vital signs, pulse, respiration, blood pressure, and shock status, are all important. Abdominal palpation is rarely satisfactory in the severely injured because of abdominal wall rigidity and accurate palpation of the kidneys is often impossible. It is most important to palpate or percuss the bladder distention before catheterization. Examination of the external genitalia by inspection and palpation should be followed by digital rectal examination. I know of no reason why this valuable step is so often neglected. Although the position of the patient cannot be ideal,

information gained concerning rupture of the membranous urethra, rectal injury, and bladder distention, is most useful.

Bleeding from the urethra usually indicates damage to the urethra distal to the bladder neck. The patient should not be encouraged to attempt urination because of the danger of extravasation in case of rupture of the urethra. When the bladder is ruptured, the patient cannot void anyhow. Urethral injury having been ruled out by examination of the urethra for blood, by palpation of the external genitalia, and by digital rectal examination, injury to the bladder must be considered. In the case of fractured pelvis, the bladder must be considered ruptured until proved otherwise. Gentle passage of a well lubricated, very soft rubber catheter, (a stiff one should never be used) is a well accredited procedure, but not used in some localities because of unfortunate experience with forceful passage of a catheter by inexperienced men. If no urine, or a very small quantity of bloody urine is obtained, we have pretty good evidence of bladder rupture, unless the patient had voided shortly before catheterization. Filling the bladder with a known quantity of sterile normal saline solution and measuring the return, is a good diagnostic method. The cystogram is also a good procedure but errors in interpretation of the X-ray films are not uncommon. It is difficult to visualize extravasated, particularly intraperitoneal iodide when the bowel is distended with gas. Cystoscopy can also be used for diagnosis but it is not feasible in severely injured patients, especially those with femoral and pelvic fractures. When abdominal exploration is indicated for internal injury with or without hemorrhage, the bladder can also be explored and the above tests may not be necessary. The scalpel is often the safest urologic instrument for diagnosis and treatment of the severely injured.

Diversion of urine by cystostomy, adequate drainage for actual or anticipated extravasation of urine, and repair of the defect, are basic principles. Suturing of bladder wounds is usually well done. Occasionally it is not wise to attempt urethral repair initially because of the precarious condition of the patient, but it seems to me a simple and short procedure to place heavy sutures on the two sides of the prostatic capsule passing them through the perineum on a straight needle to be tied over buttons, to anchor the prostate in line with the urethra as described by Leadbetter. A catheter splint must be used but I do not believe that traction on a Foley catheter is sufficient to hold a dislocated prostate in normal position. When a defect exists between the separated ends of the urethra, stricture is always a serious matter. Close approximation of the urethral mucous membrane, not necessarily watertight, will lessen stricture formation.

The Young Stone[5] procedure for repair of rectourethral fistula has been successful in my hands in 72 patients. The important points are circular incision around the anus exactly at the mucocutaneous juncture, preservation of the external anal sphincter, freeing of the rectum so that the fistula lies outside the anal margin with no traction on the bowel. Diversion of urine by cystostomy must be done, but unless a colostomy has been previously done, I do not think it necessary at the time of the Young Stone procedure. I[5] have placed stay sutures between the rectum and the deep pelvic walls to allay stress on the anal suture line.

In most instances, it is possible to repair the defect in the bladder or urethra at the time of injury. Secondary repairs of the urethra, particularly in the membranous urethra area, can be very difficult. I believe, however, that secondary repair of the urethra should be attempted even in the case of extraordinarily wide defects, with or without the complication of rectourethral fistula. The results have been extraordinarily satisfactory and I do not think that permanent diversion of the urine should ever be considered until every possible attempt has been made to repair the defect in order to restore the patient to normal living. Experience has taught me that the patient can perfectly control urination even when the external urethral sphincter has been completely destroyed.

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REFERENCES

1. Clarke, B. G., and Ledbetter, W. F.: Management of wounds and injuries of genitourinary tract: review of reported experience in World War II, J. Urol. *67:* 719 (May) 1952.
2. Fullerton, A.: History of Great War, Medical Services' Surgery of the War *1:* p. 551, His Majesty's Stationery Office, London, 1922.
3. Ledbetter, W. F.: Medical Bulletin, North African Theater, Op. 2, 70, 1949.
4. Lewis, L. G.: Cases of severe pelvic injury, Ann. Surg. *121:* 470 (April) 1945.
5. ——: Repair of recto-urethral fistulas, J. Urol. *57:* 1173 (June) 1947.
6. Lynch, K. M., Jr.: Traumatic urinary injuries, pitfalls in their diagnosis and treatment, J. Urol. *77:* 90 (Jan.) 1957.
7. Michels, L. M.: Wounds of urinary bladder; analysis of 155 cases, Ann. Surg. *123:* 999 (June) 1946.
8. Young, H. H., and Stone, H. B.: Urethro-rectal fistula, J. Urol. *1:* 289 (June) 1917.

POSTOPERATIVE WOUND INFECTIONS

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The surgeon frequently boasts of his favorable mortality rate, however, he seldom mentions his morbidity. Moreover, very little discussion is given to the topic of morbidity in surgical literature. This paucity of information prompted the present clinical study of morbidity on the Surgical Services of the Veterans Administration Hospital, Dayton, Ohio.

Postoperative morbidity, adding to the discomfort of patients, retarding their return to normalcy, and increasing their hospital stay, was assessed during the period of July 1, 1954 through June 30, 1956. This study was divided into two one-year periods for comparison. During the first year, 2,053 operations were performed. There were 107 postoperative complications with a morbidity rate of 5.2 per cent. During the second period 1,941 operations were performed. One hundred and nine complications yielded a morbidity rate of 5.6 per cent.

Tables 1 and 2 demonstrate that the most common postoperative complication was wound infection. Its incidence alone was 1.8 per cent. Whitaker has reported a rate of 3.4 per cent.[14] Altemeier reported an incidence of 1 to 5 per cent in clean surgical wounds.[1]

Since the majority of the operations were performed by the residency staff, this may account for the relatively high frequency of wound infections. A review of the clinical records reveals that no specific operation was dominant in the causation of the infection. The most common organism was micrococcus pyogenes, coagulase positive, which was found in all but 3 cases tested. It was resistant to penicillin in over 60 per cent of the cases where it was tested. It was regularly sensitive to Chloramphenicol to compare favorably with a reported sensitivity of about 96 per cent.[1] The hospital stay was prolonged from 6 to 58 days.

CAUSATIVE FACTORS

Since Lister conclusively proved that antisepsis decreased postoperative infection, surgeons have attempted to acquire complete asepsis. Although this is virtually impossible, there are controllable factors which will decrease the incidence of wound sepsis.

Preparation of Patient: Numerous articles appear in the literature apropos to the best agent to sterilize the patient's skin. Apparently some pathogens, such as S. pyogenes, may become established in deeper layers of skin as resident flora and are not reached by the disinfectants.[11] Some authors believe that a single painting of 2 per cent Iodine in 70 per cent alcohol just prior to operation will suffice.[6] They maintain that elaborate washings could be omitted for no amount

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TABLE 1

Analysis of postoperative complications

Complications	July 1954 Through June 1955	July 1955 Through June 1956
1. Postoperative infection	37	36
2. Hematoma	13	23
3. Thrombophlebitis	5	8
4. Dehiscence of wound	6	7
5. Pulmonary complications		
a. Pneumonitis and bronchitis	5	8
b. Atelectasis (requiring bronchoscopy)	4	2
c. Pulmonary embolus	3	2
d. Pneumothorax	1	0
6. Bleeding	4	5
7. Slough of skin	4	4
8. Fistulas		
a. Bronchopleural	2	1
b. Mucocutaneous	1	1
c. Parotid	1	1
d. Fecal	2	1
e. Vesicocutaneous	3	2
9. Postoperative ileus (prolonged)	3	2
10. Pancreatitis	4	2
11. Cerebral embolus	0	1
12. Cardiac arrest	2	1
13. Intraperitoneal leak	1	0
14. Gastric obstruction	3	1
15. Pseudomonas enterocolitis	0	1
16. Perforation of bladder	1	0
17. Bovie burn	1	0
18. Closed loop obstruction	1	0
Total	107	109

of washing removes all the resident bacteria. Other workers advocate Tincture of Acrizine,[9] Tincture of Cytylpyridium chloride[8] or 1 per cent Centrimide in 70 per cent industrial spirits.[13] The latter was found consistently bactericidal to S. pyogenes, Pseudomonas Aeruginosa, B. coli and B. vulgaris in 30 seconds. Seventy per cent alcohol alone and 1 per cent Aqueous Iodine produced virtual disinfection in 30 seconds.[13] Some surgeons gently wipe the skin edge about the incision every 30 minutes with swabs soaked in Acriflavine 1/1000 in water or 1 per cent Tetrachlorxyol in 70 per cent alcohol.[7] Presumably, this maintains relative disinfection about the operative wound.

At this hospital, the patient's skin was scrubbed for 10 minutes with Septisol during the first year of study. During the second year, the skin was washed alternately 6 times each with 1:1000 Aqueous Ceepryn and 70 per cent Isopropyl alcohol. There was no significant difference in the rate of postoperative wound infection. Swab cultures taken after scrubbing on several occsions failed to yield pathogens.

TABLE 3

Analysis of postoperative wound infections

Case	Diagnosis	Operation	Day Discovered	Organism	Sensitive Drug	Resis. to Penicillin	Increased Hospitalization
1	Benign prostatic hypertrophy	Prostatectomy	—	M. pyogenes	Chloromycetin Erythromycin	Yes	38 d
2	Improper A-K stump	Revised A-K stump	—	M. pyogenes	Chloromycetin Bacitracin	Yes	30 d
3	Perforated duodenal ulcer	Closure	—	Acrobacter	Chloromycetin Streptomycin	—	12 d
4	Ulcerative colitis	Total colectomy	—	Enterococci	Chloromycetin	—	35 d
5	Cooper's ligament hernioplasty	Hernioplasty	—	M. pyogenes	Achromycin Penicillin	No	20 d
6	Hydrocele	Hydrocelectomy	—	M. pyogenes	Chloromycetin	Yes	10 d
7	Sebaceous cyst	Removal of	4	M. pyogenes	Chloromycetin Achromycin	No	10 d
8	Intestinal obstruction	Lysis of adhesions	14	M. pyogenes	—	—	58 d
9	Chronic cholecystitis	Cholecystectomy	10	M. pyogenes	Chlormycetin Erythromycin	Yes	12 d
10	Compound fracture of hip	Osteosynthesis	—	M. pyogenes	Erythromycin	Yes	—
11	Bleeding peptic ulcer	Subtotal gastrectomy	37	M. pyogenes	Chloromycetin Bacitracin	Yes	6 d
12	Lumbar hernia	Herniorrhaphy	9	M. pyogenes	Chloromycetin	Yes	38 d
13	Appendicitis	Appendectomy	15	E. coli	Chloromycetin	—	—
14	Peritonitis	Expl. laparotomy	—	B. proteus	Furadontin	—	—
15	Varicose ulcers	Skin graft					
16	Varicose veins	Stripping					
17	Appendiceal abscess	Expl. laparotomy	11	M. pyogenes E. coli	Chloromycetin Achromycin	Yes	—
18	Hernia	Cooper's ligament Hernioplasty					
19	Umbilical hernia	Herniorrhaphy	10	M. pyogenes			14 d

20	Worthom's tumor (parotid gland)	Excision of tumor	4	M. pyogenes			8 d
21	Umbilical hernia	Herniorrhaphy	7	No org. grown			55 d
22	Bleeding atrophic gastritis	Subtotal gastrectomy	11	M. pyogenes			
23	Hydrocele	Hydrocelectomy	5	M. pyogenes	Erythromycin		20 d
24	Perforated appendix	Appendectomy					21 d
25	Fracture of tibia	Open reduction		Pseudomonal aeruginosa			
26	Bleeding peptic ulcer	Subtotal gastrectomy	37	M. pyogenes			

TABLE 2

Simulated preoperative sterility tests

Specimens were obtained from the skin surface of the hands and forearms up to the elbow of a doctor and nurse by the swab technic before and after scrubbing for 7 minutes with Septisol and subsequently planted onto laboratory media. Suitable incubation was effected and bacterial counts were made. The following are the results and their evaluation:

Before Scrubbing, Male Nurse	After Scrubbing, Male Nurse
#1–27	#1–2
#2–32	#2–4
#3–20	#3–1
#4–21	#4–1
#5–56	#5–5
Before Scrubbing, Doctor	**After Scrubbing, Doctor**
#1–84	#1–2
#2–24	#2–1
#3–36	#3–1
#4–18	#4–1
#5–32	#5–0

The Surgical Team: The scrub nurse, surgeon and assistants may be the source of the organism. Indeed, the patient himself or anyone who enters the operative theatre may be the culprit. Needless to say, the patient nor any member of the surgical team, should harbor an upper respiratory or superficial skin infection. Each person, including the patient, unless mode of anesthesia prevents him, should wear a mask. Perspiration not infrequently may be the source of the contaminant. Swab cultures taken from the brows of surgeons and assistants while operating have shown luxuriant growth of almost pure S. aureus.[3] For this a stockinet cap has been devised to simulate an absorbable band across the brow. It can cover the entire face, excluding nose and eyes. Septisol, Phisohex and other agents are used for scrubbing the surgeons' hands. We use a 7 minute scrub with Septisol. If the surgeon has scrubbed, or the nurse, within the preceding 24 hours, he scrubs but 3 minutes. A simple sterility test was done to demonstrate the qualitative efficacy of our procedure. Results are shown in table 2.

Rooms, Instruments and Drapes: The contents of the operating theatre harbor bacteria. Some clinics treat the air with ultraviolet light. Others filter it. These procedures lower the bacterial count. At this hospital floors are scrubbed with Nairn; tables and anesthetic machines are washed with Green soap.

The routine used in autoclaving is as follows:

Instruments—20 lb. pr. for 45 min.
Gloves (all rubber goods)—20 lb. pr. for 30 min.
Linen—20 lb. pr. for 45 min.
Suture material and brushes—20 lb. pr. for 15 min.
Syringes and needles—20 lb. pr. for 15 min.
Solution flasks—30 to 45 min.

Six cultures are taken at random monthly. In the past 3 years, only 5 positive cultures were reported. On 3 occasions Penrose drains were vehicles to transport bacteria. Sporadically, spores, dust other contaminants are placed in the autoclave for testing. Consistently the organisms are destroyed.

It is well documented that wet drapes or gowns serve as sources for the spread of bacteria. In 1943, Owens demonstrated that contamination may reach a wound through the entire thickness of a dressing.[10] In vitro studies, he proved that organisms may pass through as many as 64 thicknesses of gauze.[10] Apparently a wet drape is a contaminated drape. If moistened packs are used they should not be permitted to moisten drapes beyond the prepared field.[4] If the surgeon's gown is dampened by water or blood, it should be changed immediately. A clean, dry cloth is an aseptic barrier which loses this property when it becomes wet.[4] It appears that a layer of cellophane between moistened dressings prevents passage of organisms.[5, 7, 10]

Surgical Technic: Needless to say, good surgical technic helps preclude the development of postoperative wound complications. This technic begins with design of incision for exposure which makes rough powerful retraction unnecessary. The incision is made with a sharp blade, never scissors, to minimize tissue trauma. Hemostasis is paramount, for a hematoma predisposes to suppuration. Whenever venous oozing persists and sanguineous collections are feared, the wound should be drained for 24 to 48 hours and a compression dressing applied. The latter also promotes good venous drainage thereby decreasing edema and poor circulation, which hinders effective healing. Each clamped vessel should include a minimum of tissue because strangulated tissue becomes necrotic debris and favors sepsis.

Bruised, devascularized tissue has a proclivity to develop secondary infection. Such tissue loses its natural powers of resistance. Tissues must be handled with a delicate touch. Swabbing is done with momentary pressure without rubbing. Dissection must be sharp and gentle, never blunt and rough.

Suture material, wherever feasible, should be nonabsorbable and fine. The finest material for approximation must be used. Experimental studies where the variable factors—general resistance of the patient and degree of contamination of wound—are controlled, demonstrated that a clean wound with catgut yielded more suppuration than one with silk.[12] Of course, one always uses catgut in contaminated wounds. Silk, since it remains, acts as a foreign body and accentuates the suppurative process.

The Infective Agent: The other factor in infection is the microorganism. The most common pathogen in postoperative wound infections is S. pyogenes, coagulase positive.[1] It was found in 90 per cent of our cases in which cultures were taken. The source of this agent includes the surgeon's and nurse's hands and upper respiratory tract, instruments, gloves, gowns, swabs, sutures, air, soaked dressings or plaster of Paris.[7]

The hemolytic S. Aureus coagulates human plasma, liquefies fibrin and gelatin and produces a local necrotizing toxin.[2] Its ability to coagulate plasma initiates thrombosis and phlebitis in nearby veins. These events lower the local resistance

of tissue and increases the invasiveness of the organism. Altemeier reported that 96 per cent of the cultured organisms are sensitive to Chloromycetin.[2] In our series it was more sensitive in 90 per cent of cases tested. Interestingly enough, S. Aureus was resistant to Penicillin in about 70 per cent of the cases.

DIAGNOSIS

The wound should be observed assiduously for localized tenderness and induration. Frequently, a mild evening rise in temperature implicates a lurking wound infection. If the temperature remains elevated after 48 to 72 hours, when atelectasis and pneumonitis are most common, the wound should be carefully watched. The dressing not infrequently is stained with a seropurulent exudate. Of course, the diagnosis is readily evident when the wound opens spontaneously and drains.

That the early diagnosis of wound infections is important is indicated by the prolonged hospitalization necessary to heal them. The diagnosis was made as early as the fourth postoperative day and as late as the thirty-seventh day. The increase in hospitalized days was estimated to vary from 6 to 58 days, with an average of 24 days. This was determined by estimating 10 days as a normal convalescent period before discharge.

TREATMENT

Prophylactic Therapy: The most important treatment is preventive. This begins in the preoperative preparation of the patient. He should be reasonably well nourished and in positive nitrogen balance. His electrolytes must be balanced and his blood volume returned to normal. Anemia should be corrected. Vitamin A and C deficits must be eliminated. Vitamin A is essential in re-epithelization and ascorbic acid in deposition of collagen. Without them, wound healing is delayed and faulty, thus predisposing to infection.

All of the factors of the surgical technic discussed previously should be scrupulously adhered to, lest the operative wound become secondarily infected. The patient's skin should be scrubbed with a suitable antiseptic and sterile drapes applied. All that comes in contact with the patient's tissues including air, gloves, instruments, etc. should be sterile. Sharp dissection, hemostasis, gentle handling of tissues, drainage where indicated, avoidance of dead spaces and use of the least irritating sutures must be effected.

Active Therapy: As soon as the diagnosis is established, the skin edges should be separated to drain the locules of pus. Aspiration will not suffice because pus remains, reaccumulates and delays healing. The infected part must be widely opened and drained. The pus is sent to the laboratory for culture and sensitivity. Since over 90 per cent of the infections are produced by S. pyogenes, it may be assumed to be the causative pathogen until proved otherwise. Furthermore, since Chloromycetin is the most effective antibiotic against this organism, it should be administered until sensitivity studies indicate that another is more effective. Because in 70 per cent of our cases of M. pyogenes-infected wound infections, the pathogen was resistant to Penicillin the efficacy of its routine

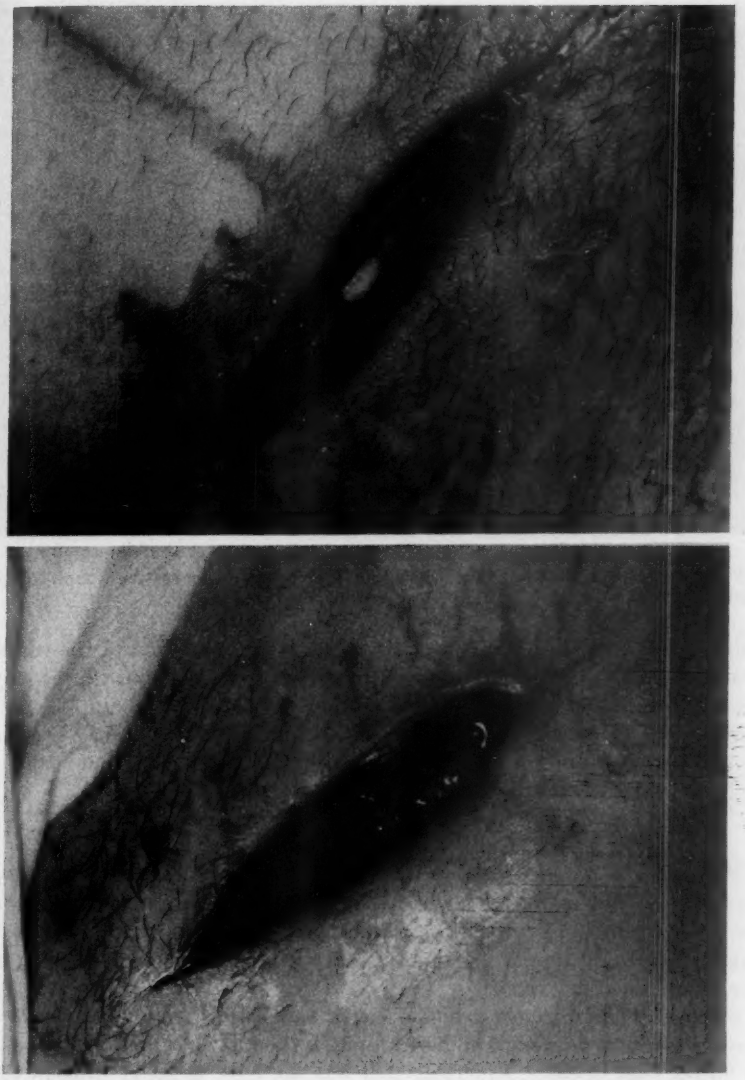
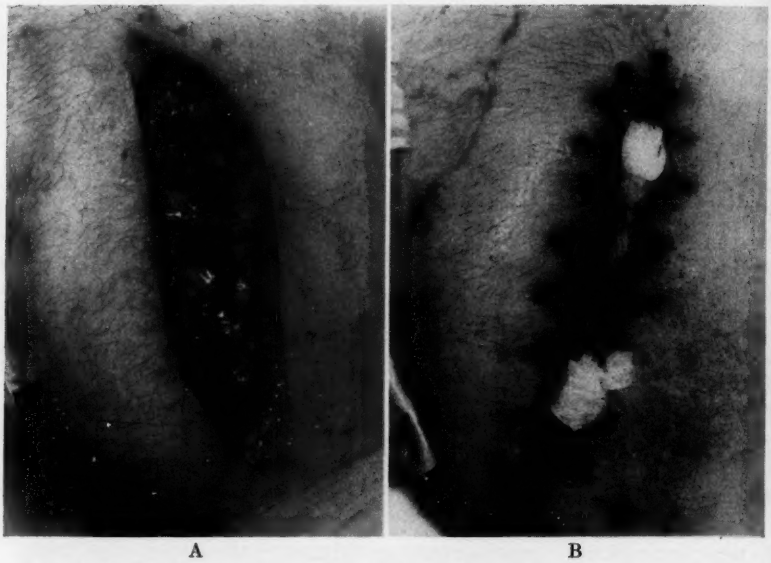


FIG. 1A & B. Two patients developed postoperative herniorraphy wound infections. They were widely opened as shown and permitted to granulate in with healing by second intention.

postoperative administration to counteract wound infection is questioned. Similarly, the often expressed value of injecting and applying Penicillin is challenged.

Needless to add, rest, elevation of the part and moist heat are adjuvants to accelerate clearing the infection and healing of the wound. If the wound is ex-



A B

FIG. 2. A. Patient had cholecystectomy and developed postoperative wound infection. Wound was opened widely. B. Secondary closure of wound.

tensive, often fine mesh gauze is used to maintain separation of the edges for adequate drainage. If the infected sinus is deep, iodoform gauze strips may be inserted to promote healing from the depth of the defect.

When the infection is cleared, coaptation of the wound edges may be effected by secondary closure with sutures of flamed tape. Otherwise, wound healing will be by second intention and much slower.

SUMMARY AND CONCLUSIONS

Postoperative wound infection was the most common cause of morbidity on the Surgical Services of the Veterans Administration Hospital, Dayton, Ohio, for the past 2 years. Patients with malnutrition, anemia, low blood volume, unbalanced electrolytes and avitaminosis have a propensity for developing complications.

Sepsis of the postoperative wound should be suspected, diagnosed and treated early. Failure to do so will prolong hospitalization. S. pyogenes was the culprit in 90 per cent of cases. Chloromycetin was the most sensitive drug in 90 per cent of the cases. It should therefore be used when the diagnosis is made, until and unless sensitivity studies indicate otherwise. Heat, elevation and rest are other measures to be taken in accelerating clearance of infection.

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REFERENCES

1. Altemeier, W. A.: Postoperative infections, S. Clin. North America *25:* 1202 (Oct.) 1945.
2. —— and Culbertson, W. R.: Prevention and control of surgical infections, S. Clin. North America *35:* 1645 (Dec.) 1955.
3. Barber, E. W.: Infection in clean surgical wounds, Rocky Mountain M. J. *43:* 23 (Jan.) 1946.
4. Beck, W. C., and Collette, T. S.: False faith in surgeon's gown and surgical drape, Am. J. Surg. *83:* 125 (Feb.) 1952.
5. Colebrook, L., and Hood, A. M.: Infection through soaked dressings, Lancet *2:* 682 (Oct. 30) 1948.
6. Gardner, A. D.: Rapid chemical disinfection of clean unwashed skin, Lancet *1:* 683 (May 11) 1946.
7. Girdleston, D. R., Bourdilion, R. B., and McFarlan, S. M.: Infection of clean surgical wounds by surgeon and from air; work and ventilation of an operating-theatre, Lancet *1:* 597 (Mar. 17) 1951.
8. Helmsworth, J. A., and Hoxworth, P. I.: Clinical appraisal of cetylpyridium chloride as a skin antiseptic, Surg. Gynec. & Obst. *5:* 80 (May) 1945.
9. Murphy, J. J., and others: Evaluation of preoperative skin preparation, Surg. Gynec & Obst. *93:* 581 (Nov.) 1951.
10. Owens, N.: Use of pressure dressings in treatment of burns and other wounds, S. Clin. North America *23:* 1354 (Oct.) 1943.
11. Price, P. B.: Bacteriology of normal skin; new quantitative test applied to study of bacterial flora and disinfectant action of mechanical cleansing, J. Infect. Dis. *63:* 301 (Nov.–Dec.) 1938.
12. Shambaugh, P., and Dunphy, J. E.: Postoperative wound infections and use of silk: experimental study, Surgery *1:* 379 (March) 1937.
13. Story, P.: Testing of skin disinfectants, Brit. M. J. *2:* 1128 (Nov. 22) 1952.
14. Whitaker, H., and Lamb, J. W. Wound complications following surgery, Am. Surgeon *19:* 953 (Oct.) 1953.

PRIMARY CARCINOMA OF THE GALLBLADDER

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Despite the recent strides in surgery, carcinoma of the gallbladder continues as one of the most uniformly lethal neoplasms in the gastrointestinal tract. At this clinic carcinoma of the gallbladder has occurred on 71 occasions in the 23 years from 1934 to 1956 inclusive, during which time 6871 primary operations were performed for gallbladder disease. The operative incidence of cancer, then, is just over 1 per cent. This incidence is in close agreement with the calculations of Arminski[1] in his comprehensive collective review of the subject.

Our necropsy reports on this subject would be invalid because many patients come from some distance and return to their homes after operation. Three large series of necropsy findings are worth quoting. Arminski found a necropsy incidence of 0.36 per cent. Lieber[7] gave the necropsy incidence as 0.47 per cent in white females, and 0.28 per cent in white males. Warren and Balch[12] calculated that 0.37 per cent of patients coming to necropsy died of carcinoma of the gallbladder. Necropsy figures are usually high for surgical conditions, as lesions such as coronary thrombosis and cerebrovascular accidents are not usually represented in their true incidence, but such figures are more accurate than operative reports. On the basis of the necropsy reports, about 1 person in 300 dies of carcinoma of the gallbladder.

The steady decline in incidence of carcinoma of the gallbladder may be attributed to the fact that cholecystectomy is performed earlier and more frequently in the course of the disease. There is also a more accurate distinction between this condition and carcinoma of the extrahepatic biliary tract and carcinoma of the pancreas. Much of the older literature on this subject refers to a combined figure of carcinoma of the gallbladder and carcinoma of the extrahepatic biliary ducts in the arguments for "prophylactic cholecystectomy." During the same period covered by this review of carcinoma of the gallbladder 81 cases of carcinoma of the extrahepatic biliary tract have been encountered. Thus the incidence of carcinoma of the extrahepatic biliary ducts was 1.2 per cent. This figure excludes carcinoma of the ampulla of Vater and primary cholangiomas of the liver.

AGE AND SEX

The age at which primary carcinoma occurs corresponds closely to that for the general age group with carcinoma. In our series the average age was 60.8 years. Age is important, as only 13 of our patients (18.3 per cent) were under the age of 55 years. Our youngest patient was a man of 42, and our oldest was a woman of 81. Almost exactly 50 per cent of the women and 43 per cent of the men were in the seventh decade.

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We have had 54 women and 17 men, or a ratio of approximately 3 to 1. Arminski gives a collected average of 3 women to 1 man. Our sex ratio for cholelithiasis is 3 women to 1 man.

CLINICAL FINDINGS

There is no distinct clinical picture of primary carcinoma of the gallbladder, but it tends to follow one of two patterns. The first is that in which the symptoms of chronic cholecystitis and cholelithiasis have been present for years and have recently become exacerbated. The second group is that in which symptoms have been of short duration. A third category, a small one, is made up of those in which the gallbladder has been removed for cholelithiasis and a microscopic diagnosis of carcinoma is made by the pathologist. All patients surviving any appreciable length of time fall in this third group.

Previous History of Gallstones: In 32 of our cases (45 per cent) there was a reliable history of gallbladder disease for from 1 to 37 years previously. In a number of cases, patients had previously had cholecystograms with positive findings of gallstones and had been advised to have their gallbladders removed but failed to have an operation.

Pain: Pain was the most constant symptom. It was present in 64 of 71 patients (90 per cent). The site varied; the right upper quadrant, the epigastrium, the back and the right shoulder blade were the commonest sites in that order. The quality of the pain varied with the extent of the disease although many patients gave a typical history of repeated attacks of gallbladder colic.

Loss of Weight: Loss of weight occurred in 46 (65 per cent) of our patients. The loss varied from 10 to 60 pounds and 26 patients (37 per cent) had lost 20 pounds or more.

On examination 37 patients (52 per cent) had a mass in the right upper quadrant. This mass varied in size from patient to patient and the size of the mass could not be correlated with the duration of the history.

Twenty-six patients, almost 37 per cent, had jaundice varying in duration from 1 day to 6 months. Seven patients (10 per cent) had jaundice without any other positive physical finding. In 4 patients, the only positive finding was a tender but normal sized liver. These tender livers proved to be the site of metastases.

Four patients came to us with a previous history of cholecystostomy. In all 4, removal of the gallbladder was still possible, but in no case did a cure result. This incidence (5.6 per cent) of cholecystostomies in our series is probably falsely high as it was a common operation in community hospitals during the thirties and forties.

LABORATORY FINDINGS

Laboratory findings were noncontributory as might be expected. Many of the patients had cholecystography but in only 1 case was a probable diagnosis of carcinoma of the gallbladder made roentgenographically (fig. 1). When studies were made, the gallbladder was reported as nonfunctioning.

FIG. 1. Outline of gallbladder shows deformity, suggestive of neoplasm; carcinoma simplex involving the gallbladder was found at operation.

The gallbladder may be enlarged, it may appear normal or it may be invisible under a huge mass of neoplastic tissue.

On microscopic study the neoplasm was an adenocarcinoma in 40 cases (56 per cent). It was carcinoma simplex in 22 cases (31 per cent) and an epidermoid carcinoma or adenoacanthoma in 8 cases (11 per cent). Grading of the neoplasms is not considered to be of any value in this condition.

RESULTS OF SURGERY

Exploration or biopsy only was performed in 35 of the 71 patients. Further procedures were performed in the remaining 36. In only 15 patients, approximately 21 per cent of the total 71 cases, the gallbladder was removed; this was combined with a choledochostomy if indicated. In 7 patients, a cholecystostomy was performed with or without exploration of the common bile duct and in the remaining 14 patients, the common bile duct was explored and drained. This grim picture in which absolutely nothing could be done for half the patients presenting themselves for surgery shows the magnitude of the problem.

Six patients died within a week and a total of 16 within a month following operation. Those who survived longer than a month lived an average of 3 months after operation. The maximal period was 8 months. Excluded from this group, however, are those who survived longer and they will be considered later in this paper. The 15 patients who had cholecystectomy as a primary procedure survived an average of 7 months.

Gallstones: In 42 patients (59 per cent) gallstones were definitely present in the malignant gallbladder. In an additional 23 patients, it was uncertain whether stones were present. It was difficult in the presence of large tumor masses to decide upon the presence or absence of calculi, a fact which has been referred to by Finney and Johnson.[6] In 4 patients (5.6 per cent) gallstones were absent. In 2 other patients in this series of 71 cases of carcinoma of the gallbladder, a malignant adenoma was found in the gallbladder and cholecystectomy was performed.

Papillomas of the gallbladder are probably more common than adenomas (fig. 2). It has never been conclusively shown, however, that papillomas are premalignant, although it is safer from the clinical standpoint to regard them as such. Modern pathologic criteria would undoubtedly eliminate many of the cases of papilloma given in older reports. The treatment, however, is cholecystectomy, not only because of the possibility of cancer but of the associated pathologic changes (fig. 3). Adenoma of the gallbladder is very rare.[8, 9]

The most controversial question in the entire subject of carcinoma of the gallbladder is its association with cholelithiasis. We have already referred to its incidence in the general population. Lieber[7] found that gallstones occurred in 27.8 per cent of white females over 50, and 12.4 per cent of white males over 50. His figures also show that carcinoma of the gallbladder was five times more common when gallstones were present. It is accepted, then, that the chance of cancer developing is greater in a gallbladder with stones than in one without, but that the stones themselves can cause cancer is not wholly accepted by internists, general practitioners, and experimentalists. The experimental evidence is either negative or inconclusive. No attempt has been made in any of the reports encountered to distinguish between the various types of stones found in

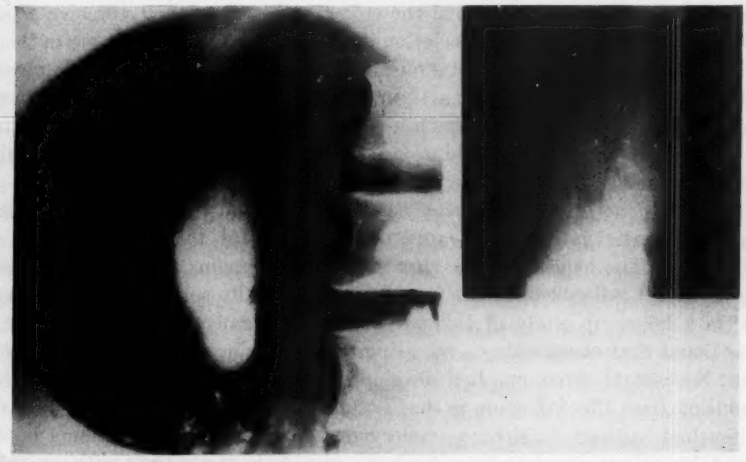

FIG. 2. Multiple polyps of the gallbladder. Multiple small irregular defects are scattered throughout the gallbladder. Cholecystectomy was performed. The pathologic diagnosis was multiple inflammatory polyps.

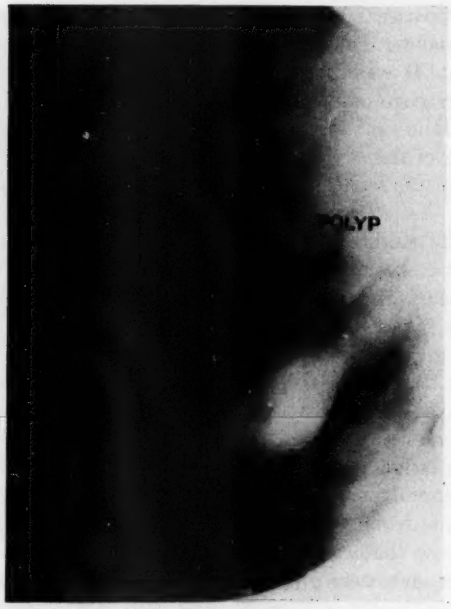

FIG. 3. Single polyp of the gallbladder. The gallbladder was visualized with a single dose of dye; a small negative defect, 7 mm. in diameter, was present in the wall of the gallbladder.

neoplastic gallbladders. Mixed stones of infective origin, and cholesterol and pigment stones of metabolic origin are all considered together. It appears more likely that it is the constituents of the stones rather than their abrasive action which is responsible for their association with carcinoma. Gallstones are in themselves evidence of defective metabolism, and we know that chemicals closely related to cholesterol and cholic acid may act as carcinogenic agents. The neoplasms caused by abrasion are much less common than previously thought, and the origin of the neoplasm would appear to lie in disordered metabolism which causes gallstones or carcinoma or both.

Silent Gallstone: Much controversy rages around the treatment of the silent or asymptomatic gallstone. A more realistic title for this variety would be "quiescent." The length of time that a gallstone remains symptomless cannot be guaranteed. All gallstones are harmful or potentially so. Comfort and associates[4] in a follow-up study of 112 cases of "silent" gallstones of from 10 to 25 years found that complications requiring operation developed in 25 per cent of them. No case of carcinoma had developed in that series in the interim. Their conclusion from this follow-up is that a number of lives might have been saved if they had insisted on elective cholecystectomy. As far as carcinoma is concerned, logically a neoplasm is as likely to develop in the patient without symptoms as in the patient with symptoms, but the silent gallstone may, and fre-

quently does, cause acute cholecystitis, migration of calculi into the common bile duct and perforation of the gallbladder, which are serious complications in an older age group. Some of these complications require emergency operations, which the aged do not withstand as well as an elective procedure.

Frequently the possessor of a silent gallstone has developed an increasing tolerance to digestive upsets over the years. Internists, especially, seem unwilling to advise cholecystectomy unless dramatic episodes such as acute cholecystitis or biliary colic have occurred, but if the operation is carried out for the so-called silent stones it will be found that the well-being of these patients is greatly improved. They are raised up from a plane of subhealth into which they had gradually descended, and it is only subsequently that it is revealed that the voluntary dietary restrictions, which have been self-imposed for many years, can now be discontinued.

Cooke and associates[3] stated "12 per cent of patients found at necropsy to have a gallstone died of complications arising from the gallstone." Swinton and Becker[10] stated that the policy of cholecystectomy (at this clinic) "is based more on the probability of the later development of symptoms from the gallstones, digestive or colic, than on the probability of the development of the rare case of carcinoma of the gallbladder." We endorse this statement, and we would say that the mortality for "prophylactic" cholecystectomy is considerably lower than the mortality of benign and malignant complications of cholelithiasis.[2] The mortality rate (from 1942 to 1948) for 2123 cases of cholecystectomy for gallstones associated with all forms of complications is 1.1 per cent.

Three of the 71 patients survived for 5 years. One patient died 11 years later of carcinoma of the colon. This patient had a wedge resection of the liver at the time of removal of the gallbladder. One other patient who had a cholecystectomy and an adenocarcinoma was found on microscopic study, did well for 38 months. Multiple metastases were found at exploratory laparotomy.

CONCLUSIONS

Primary carcinoma of the gallbladder occurred in 71 of 6871 primary operations on the biliary tract performed between 1934 and 1956, inclusive, an incidence of 1.03 per cent. Carcinoma of the bile ducts occurred in 81 patients in the same operative series, an incidence of 1.18 per cent. The incidence, sex ratio, age, signs and symptoms, and results of treatment are analyzed. They are comparable to the majority of the published series. Carcinoma simplex was considerably more common in our series than in the usual published reports. The high initial mortality and short survival period of these patients appear uniform. The incidence of gallstones in the age group in which carcinoma of the gallbladder is most common and in the actual cases of carcinoma of the gallbladder is discussed. Carcinoma is five times more common in gallbladders with than in those without stones. The association of carcinoma with gallstones probably is based on the metabolic disorders that cause the stones rather than on their abrasive action. The asymptomatic gallbladder is just as likely as the symptomatic gallbladder to develop benign and malignant complications.

Papillomas of the gallbladder should be regarded as premalignant from the clinical point of view. Cholecystectomy should be performed in every case.

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REFERENCES

1. Arminski, T. C.: Primary carcinoma of gallbladder; collective review with addition of 25 cases from Grace Hospital, Detroit, Michigan, Cancer *2:* 379 (May) 1949.
2. Colcock, B. P., and McManus, J. E.: Experiences with 1,356 cases of cholecystitis and cholelithiasis, Surg., Gynec. & Obst. *101:* 161 (Aug.) 1955.
3. Cooke, L., Jones, F. A., and Keech, M. K.: Carcinoma of gall-bladder; statistical study, Lancet *2:* 585 (Sept. 19) 1953.
4. Comfort, M. W., Gray, H. K., and Wilson, J. M.: Silent gallstone; a 10 to 20 year follow-up study of 112 cases, Ann. Surg. *128:* 931 (Nov.) 1948.
5. Donald, J. A., and Fitts, W. T., Jr.: Cholecystostomy; study of patients 10 to 16 years later, Am. J. Surg. *77:* 596 (May) 1949.
6. Finney, J. M. T., Jr., and Johnson, M. L.: Primary carcinoma of gallbladder; additional reason for early removal of calculous gallbladder, Tr. South. S. A. (1944) *56:* 41, 1945.
7. Lieber, M. M.: Incidence of gallstones and their correlation with other diseases, Ann. Surg. *135:* 394 (March) 1952.
8. Phillips, J. R.: Papilloma of gall bladder, Am. J. Surg. *21:* 38 (July) 1933.
9. Shepherd, V. D., Walters, W., and Dockerty, M. B.: Benign neoplasm of gallbladder, Arch. Surg. *45:* 1 (July) 1942.
10. Swinton, N. W., and Becker, W. F.: Tumors of gallbladder, S. Clin. North America *28:* 669 (June) 1948.
11. Tragerman, L. J.: Primary carcinoma of gallbladder; review of 173 cases, California Med. *78:* 431 (May) 1953.
12. Warren, R., and Balch, F. G., Jr.: Carcinoma of gallbladder; etiological role of gallstones, Surgery *7:* 657 (May) 1940.

THE PROBLEM OF THE BLEEDING NIPPLE ASSOCIATED WITH AN OTHERWISE NORMAL BREAST

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One of the most difficult problems to confront the surgeon in the care of lesions of the breast is presented by the nonlactating patient with a discharging nipple associated with an otherwise normal breast. Where there is an associated mass in the breast, there is no problem. The mass itself takes precedence and determines the method of treatment. However, when there is no mass and a discharging nipple, the decision of what to do for the patient can at times be most difficult. It is desirable not to needlessly alarm the patient or to perform unnecessary surgery, yet we cannot afford to overlook an early carcinoma of the breast.

A small amount of nipple discharge from the nonlactating breast of a woman in the child-bearing period is not uncommon. Such a discharge may be clear, cloudy, greenish-brown or almost black. It may or may not contain blood. The patient who has such a discharge usually presents herself for examination shortly after noticing a stain on her clothing. She is often quite alarmed by this discovery.

In every case, the discharge should be examined by a pathologist for the presence of blood and also for cell study. If it contains only secretory elements, fat, and desquamated epithelial cells, it is generally considered to be of no significance. If it is serous or serosanguinous or contains hyperplastic epithelial cells, it is probably due to an intraductile papilloma and it may even be due to carcinoma. It is with this latter type of discharge, the serosanguinous discharge, that we are principally concerned.

Donnelly[5] divides nipple discharge into two types—(1) stagnation and exfoliative and (2) hyperplastic. The stagnation type is due to cystic mastitis and is white, yellow, green or brown and nonsanguinous. The hyperplastic type is serous or serosanguinous and shows a heaping up of epithelium producing papillary invaginations, papilloma or carcinoma.

There is a misconception that a serous discharge indicates a benign condition whereas a bloody discharge may mean carcinoma. No such distinction is possible. A benign papilloma may produce a serous or a sanguinous discharge and intraductile carcinoma may also produce a serous or sanguinous discharge. A discharge that is serous today may be sanguinous when the patient is next seen. So we cannot depend on the gross nature of the discharge to make a diagnosis of the underlying pathology. Most bloody discharges from the nipple will be due to intraductile papilloma but can also be due to carcinoma.

It is said to be possible at times, by cytologic study of nipple secretions, to

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make a diagnosis of cancer of the breast.[7] Our experience with this method has not been extensive enough for us to depend on it alone.

Nipple discharge is reported to occur in from 7 to 10 per cent of all lesions of the breast, however most of these patients have an associated mass in the breast.

Those of us who see much cancer of the breast know that nipple discharge is an uncommon finding in the patient who presents herself with breast cancer. In the past 10 years, I have seen in our little tumor clinic 476 patients with cancer of the breast. Only 3 of these complained of nipple discharge and all except one had visual or palpable evidence of breast cancer. The one patient whose breast appeared normal had a hard, enlarged axillary node, biopsy of which showed carcinoma. Radical mastectomy then revealed a tiny primary malignancy within the breast.

Braund[3] reports 163 patients with nipple discharge, 20 of whom had carcinoma and only 1 of the 20 failed to have a palpable mass in the breast. That one patient had a bloody discharge. She failed to return as instructed and when seen 2 years later had advanced cancer of the breast.

What should we do about the patient who has a serosanguinous discharge from the nipple and no visual or palpable lesion of the breast? If we turn to the literature for advice as to what to do, we may be more confused than ever, for in the literature we will find the widest possible range of opinions. Some believe that nipple discharge without a mass is not significant and others believe that it is very significant and therefore advocate simple mastectomy in every case.

For example, Bloodgood[2] in 1922 expressed the opinion that "bleeding is only a symptom and without a palpable mass does not demand treatment".

In 1951 Haagensen, Stout and Phillips[9] said that "if a patient develops a bloody or serous discharge from the nipple and careful palpation fails to reveal any tumor in the breast, it can safely be assumed that such a patient does not have a carcinoma". They do, however, assume the patient has an intraductal papilloma and proceed to find and remove it.

Campbell,[4] Slaughter and Peterson[11] advise conservative treatment for the patient with nipple discharge.

On the other hand Estes and Phillips[6] say that in 50 per cent of cases of bleeding nipple a malignant lesion is discovered at surgery. They urge surgery in every case and advise simple mastectomy.

Donnelly[5] reports 36 patients with sanguinous discharge from the nipple and no palpable mass in the breast. Thirty of these patients had evidence of hyperplasia and 5 had malignant lesions. He expressed the belief that a patient with serosanguinous discharge from the nipple and no palpable mass has a 50 per cent chance of having then or developing later carcinoma of that breast. He urges simple mastectomy initially.

Gray and Wood[8] in 1941 reported 227 cases of papilloma of the breast. About half were malignant and of these 48 per cent had no demonstrable tumor mass. McCarty, the pathologist, thought that a continued serous or bloody discharge was an indication for simple mastectomy to be followed by radical mastectomy if the lesion was malignant.

Fleming[7] takes a more moderate position. He advocates examination of the nipple discharge and if marked hyperplasia or atypical cells or papilloma cell clusters are found, exploration of the ducts is advised.

Why should there be such a wide difference of opinion as to the significance of nipple discharge not associated with palpable breast pathology? Possibly this wide divergence of opinion stems from the fact that different pathologists examine these tissues. It is quite difficult to differentiate a benign papilloma from a low grade carcinoma. One pathologist may be calling malignant what another is calling benign.

When we are faced with a serous or serosanguinous discharge, even though there is no palpable mass in the breast and especially if the woman is over 40 years of age, we rely on exploration of the duct from which the abnormal discharge issues. It is usually a relatively simple procedure to cannulate the duct with a No. 00 lacrymal probe or the blunt end of a milliner's needle. Babcock[1] described this procedure in 1938. An incision can then be made in the breast lateral to the areola and the duct and its ramifications are exposed. There is usually a brownish discoloration of the involved duct making it easily visualized. When the duct is opened and followed, one or more intraductile papillomas are often found. In one patient we found multiple stone-like concretions in the duct.

The surgeon must then decide for himself, based on the extent of involvement, whether to excise a single papilloma or to do a wedge resection of the involved portion of the breast.

It must be remembered that papillomas are frequently multiple. Some reports say they are multiple in as high as 30 per cent of cases. They vary in size from microscopic dimensions up to a few centimeters in diameter. The fact that they are so often multiple rather than single is one reason why Estes and Phillips urge simple mastectomy. They report 87 patients with intraductile papilloma of whom 42 were treated by simple mastectomy. These patients had no further trouble, while of the 34 patients treated by local or wedge resection, 12 per cent had further trouble with papilloma necessitating additional surgery. They believe that the patient should be advised she may have further trouble unless simple mastectomy is carried out.

There seems to be general agreement that as a woman grows older a serous or serosanguinous discharge from the nipple is more likely to be due to carcinoma. Over the age of 60 years, simple mastectomy is perhaps the initial treatment of choice but the real problem is what to do with the younger woman with a serosanguinous discharge and no other breast abnormality.

For these younger women, we are presently doing a duct exploration if possible, with local or wedge resection of the breast. We believe that this is especially important if the patient is over 40 years of age.

Kilgore[10] reports that 5 per cent of women with a bloody discharge and no mass have carcinoma. He suggests mastectomy for any woman over 40 but believes that she should be allowed to accept the risk of a local or wedge resection.

The present cure rate of cancer of the breast leaves much to be desired. With this in mind, even though we know that most cases of serosanguinous discharge

from the nipple unassociated with a palpable mass in the breast are due to benign papilloma, we believe that the source of the discharge should always be determined. While the first sign of cancer of the breast is usually a palpable mass, we must not fall into thinking that this is necessarily the first sign of cancer of the breast. We must remember that the first sign of breast cancer may be slight dimpling or edema of the skin, nipple retraction or crusting, an enlarged firm axillary node which is already the seat of metastasis, or the first sign of cancer may be a serous or serosanguinous discharge from the nipple.

SUMMARY

The literature pertaining to the significance of serosanguinous discharge from the nipple of an otherwise normal breast is most confusing.

While the cause of such a serosanguinous discharge is usually benign papillary disease, it may at times be due to carcinoma.

Since the presence of cancer is a possibility, we believe that the source of the discharge should be explained in every patient, especially in women over 40 years of age.

Exploration of the involved duct by means of cannulation of the duct and an incision into the breast is usually a relatively simple procedure and will frequently lead to the discovery of one or more papillomas. Further treatment should then consist of local or wedge excision or simple mastectomy, depending on the findings in the individual case and upon the surgeon's interpretation of the contradictory literature available on this subject.

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REFERENCES

1. Babcock, W. W.: Simple operation for discharging nipple, Surgery *4:* 914 (Dec.) 1938.
2. Bloodgood, J. C.: Benign lesions of female breast for which operation is not indicated, J.A.M.A. *78:* 859 (March 25) 1922.
3. Braund, R. R., and Pigott, J. D.: Clinical significance of nipple discharge in non lactating breast; Division of Surgery, University of Tennessee School of Medicine, Memphis, Tenn.
4. Campbell, O. J.: Bleeding nipple, Surgery *19:* 40 (Jan.) 1946.
5. Donnelly, B. A.: Nipple discharge; its clinical and pathological significance, Ann. Surg. *131:* 342 (March) 1950.
6. Estes, A. C., and Phillips, C.: Papilloma of lacteal duct, Surg., Gynec. & Obst. *89:* 345 (Sept.) 1949.
7. Fleming, R. M.: Cytological studies in lesions of breast; findings in nipple secretion and aspirates from tumors, South. M. J. *48:* 74 (Jan.) 1955.
8. Gray, H. K., and Wood, G. A.: Significance of mammary discharge in cases of papilloma of breast; clinical pathological study, Arch. Surg. *42:* 203 (Feb.) 1941.
9. Haagensen, C. D., Stout, A. P., and Phillips, J. S.: Papillary neoplasms of breast, I. Benign intraductile papilloma, Ann. Surg. *133:* 18 (Jan.) 1951.
10. Kilgore, A. R., Fleming, R., and Ramos, M. M.: Incidence of cancer with nipple discharge and risk of cancer in presence of papillary disease of breast, Surg., Gynec & Obst. *102:* 649 (June) 1956.
11. Slaughter, D. P., and Peterson, L. W.: Indications for simple mastectomy, Surg., Gynec. & Obst. *85:* 456 (Oct.) 1947.

THE INDUCTION OF PLEURAL SYMPHYSIS WITH PARTICULAR REFERENCE TO THERAPY FOR IRRESECTABLE MALIGNANCY

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We believe that it is mandatory when a thorax is opened for what proves to be irresectable malignancy, or for any other condition which may cause recurrent pleural effusions or empyema, that the surgeon obliterate the pleural cavity before closing the thorax by abrading all parietal surfaces with dry gauze. We not only have abundant proof of the effectiveness of this maneuver when propperly performed, but there is also 30 years of experience to show that it produces no complications of its own nor even materially impedes later transpleural surgery. Finally we can show by the most precise pulmonary function studies that this technic for pleural symphysis causes no detectable loss of pulmonary function.[3] The reason for this seems to us clear, for if the occasion does arise to reopen a chest after this type of pleural obliteration, one is forcibly struck by the fact that the lung is seen to be gliding freely back and forth with respiration as the final layer of parietal pleura is incised. The casual observer would assume that the obliteration had failed, and yet not the tiniest area of truly free pleura can be found on further exploration. This is admittedly in marked contrast to the situation found when the thorax is opened after other and more chronic irritants have acted on the pleura, and when some degree of fibrothorax is present; it has long been known that mere presence of a therapeutic pneumothorax for many months can produce as much as 30 per cent loss of function, when the lung has been re-expanded, even though the pleural density on routine roentgenograms is deceptively almost unaltered.

It is quite true that in the present state of our science most of the patients with unresected malignant growths eventually die in spite of delaying and palliating use of radiotherapy and chemotherapy, but we may at least lift from them the burden of recurrent dyspnea, pain, loss of serum proteins and ever present danger of infection by eliminating the recurrence of pleural effusion requiring repeated thoracenteses.

The application of this technic to cancer cases was undertaken by me 5 years ago, but I have since learned of a number of surgeons who are even resecting the pleura on these occasions; thus I make no claims for priority on this point. These surgeons tell me they have not had accidents such as false entry into the esophagus (which has certainly long been recognized as a real hazard) or into the vena cava. While it is quite true that such an accident is usually reparable, I am unable to see the need for such a drastic step when the use of gauze abrasion is so effective, quick, and safe. Skimming a surface crop of tumor cells by

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pleurectomy when the deep lymphatics are admittedly loaded is to me, in most cases, of dubious real benefit at best. Since gauze abrasion was mentioned as far back as 1925 in the text on thoracic surgery by Lilienthal published in that year,[2] the need for this present paper might be questioned; however, we still have many good hospitals where there is neglect of it entirely, and, what seems even worse, extensive pulmonary resections are being done in the presence of malignancy acknowledged to be irresectable.

Palliative resection of pulmonary malignancy is, in the great majority of cases, unjustified, although the radiotherapist for example may make what at first glance seems a reasonable plea to resect as much tumor as possible to minimize the tissue left as his target. The grave ultimate prognosis in these cases does not justify the surgeon in accepting even the low risk of partial resections unless there is something clearly to be gained, since it is not his place to offer the patient escape by this means, and there are no resections without some risk of morbidity. If the resection is so extensive as to leave an unfilled cavity under these circumstances, then the surgeon is on shaky ground indeed. I recently heard of a thoracotomy at which great sheets of tumor were found invading the chest wall at several points, and yet right pneumonectomy was done. The surgeon had a demonstration of the fact that right pneumonectomy is far more often followed by trouble than left when the patient died the following day. This patient had lost a lung which still had considerable direct and indirect function in exchange for a huge cavity which would have refilled rapidly as the chest wall and mediastinal lymphatics became inexorably blocked by tumor, requiring frequent adjustment of pressure by thoracenteses. This point need not be labored, as thoracic surgeons have been through this agonizing problem so many times.

We have tried nitrogen mustard, thiotepa, and the currently popular radioactive agents in the treatment of these patients. We have obtained no cures and the palliation has paralleled that reported by other authors. Simon found radioactive gold gave favorable results in less than half of his patients with carcinomatous effusion, with only 2 of 8 cases of carcinoma of the lung benefited.[6] Weisberger and his associates commented that there was no radiation hazard to personnel in using nitrogen mustard, but found only 18 of 30 patients improved.[8] Using the isotopes, Kent found 16 cases with good results and 5 improved in 112 patients with pleural effusion,[1] while Schick and Bloor noted slowing of fluid production in two-thirds of their 18 patients, using the gold.[5]

At the last meeting of the American Association for Thoracic Surgery, Doctor R. L. Kemler cited the case of a patient with an effusion containing malignant cells that required a tap every 10 days. He was given x-ray therapy, radioactive gold, and nitrogen mustard; yet the effusion continued to reaccumulate rapidly. Decortication was then done, and the patient lived very comfortably for a year and a half with no further tapping. At the same meeting Doctor Paul Samson mentioned 2 young children who required aspiration every third or fourth day. Each had x-ray therapy without success, but after decortication had permitted re-expansion of the lung and adherence, no further thoracenteses were necessary

until they died of the disease. Doctor James Dailey of Houston stated that he has been performing parietal pleurectomy almost routinely with gratifying results, not only eliminating further aspirations but also reducing pain. Doctor R. R. Meade then told of a case in which thoracotomy itself, without decortication, had apparently been sufficient to eliminate the effusion. Since Doctor David Waterman,[7] in the paper which occasioned the above remarks, mentioned one patient who may have had his death speeded by opening new channels for spread of malignant growth by decortication, we repeat our plea for proper application of simple and safe dry gauze abrasion as the middle course which does not go from one extreme, that of neglect, to another.

We might briefly review possible objections to its use. We have consistently found no postoperative pain referable to pleural abrasion. Apparently pleuritis is painful only when the irritating agent is still operating. As to dissemination of tumor cells, we can only say that we have not found such seeding clinically nor at autopsy, and believe that the danger is not only much less than that from frank pleurectomy, but is far outweighed by the very real benefits. Use of irritants such as talc has not appealed to us because of inevitable irregularities of distribution, and inability to control, at least occasionally, late continuation of fibrosis long after the simple requirement is met of adhesion at all points.

The gauze abrasion has been completely reliable if applied thoroughly with sufficient vigor to produce capillary oozing at all points (fig. 1), provided that the lung is then promptly maintained in expansion by properly placed multiple drainage tubes under continuous suction. We have found that even carcinomatous plaques will adhere when their surface has been abraded. This brings us to proof of the absence of function loss, early and late, although the latter is less important in the presence of incurable neoplasms. To check function changes derived solely from the thoracotomy and abrasion, one must find a patient without other pathology or surgery which might affect pulmonary function, an ob-

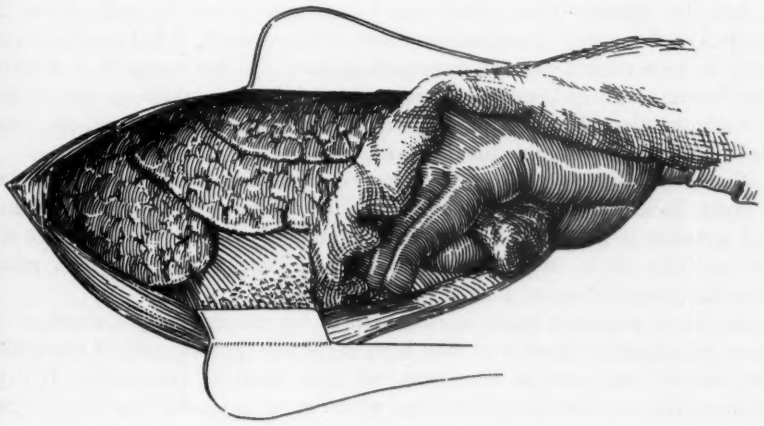

FIG. 1

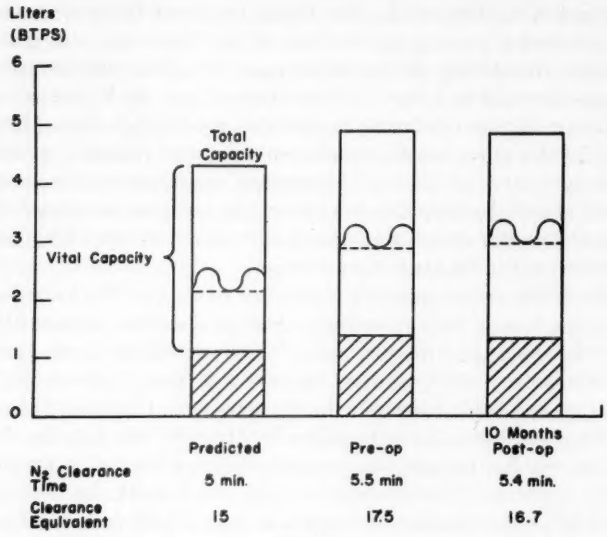

FIG. 2

viously severe limitation, so as to compare the preoperative and early and late postoperative values. We were recently fortunate in treating a healthy young woman for recurrent spontaneous pneumothoraces, found at thoracotomy to arise from a small apical bleb which was readily ligated, and the findings in her case confirm our previously reported cases. Her function was tested on our nitrogen meter, which gives precise and reproducible results, before the thoracotomy and 8 months later. The total capacity and vital capacity excursions were found the same, and there was no change in the factors for ventilatory efficiency (fig. 2). In fact the clearance time, which was 5.5 minutes before the surgery, was 5.4 minutes at the second examination. Caution is necessary, if full function is desired, to keep pleural pockets evacuated so they will not organize as a partial fibrothorax, and deep breathing exercises are helpful in minimizing changes such as costophrenic adhesions. These occasionally appear anyway without necessarily producing detectable function loss.

We now mention extension of this procedure to thoracotomies in which there is heart disease and possible later congestive failure with crippling effusions, and certainly to infectious conditions which might produce empyema. We may now ask why we do not take the final and seemingly inevitable step of recommending pleural abrasion after all thoracotomies.

Misplaced adhesions stand incriminated as the enemy of the abdominal surgeon, but properly distributed they have saved the thoracic patient times without number, and perhaps we should call upon them far more often. It is the random adhesion, and the fibrothorax, which gives us trouble, but the complete

obliteration afforded by the gliding adhesions from abrasion can offer invaluable protection.

The use of pleural obliteration in routine thoracotomy is of such wide import that it would seem to merit most careful consideration. It should particularly have study by surgeons who have the occasional case with minimal complicating pathology and who have available facilities for complete and accurate pulmonary function studies. They should of course give the procedure a fair trial by seeing that the abrasion has been performed thoroughly and in conjunction with a function-preserving incision such as the one I described several years ago,[4] unless there has been adequate testing of the effect on function of the incision of their choice.

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REFERENCES

1. Kent, E. M., and others: Radioactive isotopes in management of carcinomatosis of serous body cavities, Arch. Int. Med. *94:* 334 (Sept.) 1954.
2. Lilienthal, H.: Thoracic Surgery, Philadelphia, W. B. Saunders Co. *2:* 162, 1925.
3. MacQuigg, R. E.: Spontaneous pneumothorax: case for early thoracotomy, Am. Surgeon *21:* 478 (May) 1955.
4. ——: Transperiosteal intercostal incision, Am. Surgeon *20:* 619 (June) 1954.
5. Schick, A., and Bloor, R. J.: Control of malignant effusions with radioactive gold, N. Y. J. Med. *54:* 2979 (Nov. 1) 1954.
6. Simon, N.: Radioactive gold treatment: results in 85 effusions due to cancer, J. Mt. Sinai Hosp. *22:* 96 (July–Aug.) 1955.
7. Waterman, D. H., Domm, S. E., and Rogers, W. K.: Clinical evaluation of decortication, J. Thorac. Surg. *33:* 1 (Jan.) 1957.
8. Weisberger, A. S., Levine, B., and Storaasli, J. P.: Use of nitrogen mustard in treatment of serous effusions of neoplastic origin, J.A.M.A. *159:* 1704 (Dec. 31) 1955.

A CRITICAL ANALYSIS OF THE PROBLEM OF EXTRACORPOREAL OXYGENATION OF THE BLOOD

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A pump-oxygenator to by-pass temporarily the heart and lungs has progressed beyond the stage of being a momentary physiologic stunt. The period of successful by-pass has exceeded an hour, but not without serious hazards. Much remains to be understood and explained. Intracardiac surgery upon the open bloodless heart is moving beyond limited application. This accomplishment is not due to any few recent developments, but it has come quite logically from a long chain of small individual ideas and observations.

This paper will confine itself to the discussion of some of the basic problems resulting from the extracorporeal handling of blood. Adequate oxygenation with minimal trauma to the blood is mandatory if physiologic abnormalities are to be kept within tolerable limits or avoided. These requirements will best be met by equipment having few moving parts and needing little donor blood to prime it. The machine should be readily dismantled and constructed of durable or expendable materials.

The entire maneuver of extracorporeal oxygenation and whole body perfusion can be divided into several operations:

(1.) Priming the pump-oxygenator,
(2.) Removal of venous blood from the recipient,
(3.) Oxygenation and decarbonization of the blood,
(4.) Separation of the liquid-gas phases and particulate matter,
(5.) Pumping of blood back to recipient so as to maintain adequate blood pressure and not overload the vascular bed,
(6.) Control of the acid-base balance,
(7.) Cardiac control during open heart surgery,
(8.) Neutralization of anticoagulants (heparin) in the blood

The adult human lung has an estimated surface area of 70 to 140 square meters across which oxygen and carbon dioxide diffuse to maintain respiratory balance.[1] The relatively slow rate of diffusion of gases through inert membranes requires this oxygenation and decarbonization to be accomplished extracorporeally by filming the blood on various types of surfaces in contact with oxygen, bubbling oxygen through the blood and mixing blood and oxygen without bubbling. Parabiotic oxygenation has been done with some success.[2]

An oxygenating chamber or atmosphere containing 2 per cent to 5 per cent carbon dioxide is probably preferable to 100 percent oxygen even though metabolic acidosis tends to develop during whole body perfusion.

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PRIMING THE PUMP-OXYGENATOR

There may be certain advantages in maintaining a low volume of blood in the extracorporeal circuit.[13] The collections of large quantities of freshly drawn, compatible blood is in itself a major undertaking. Transfusion reactions continue always present. The low extracorporeal volume facilitates the maintenance of normal body temperature without additional temperature regulating apparatus. Maintenance of near normal body temperature is important in preventing the adverse effects on cardiac rhythm frequently noted with use of hypothermia. Furthermore, the low extracorporeal volume is easier to monitor. The apparatus must be filled and in operation smoothly, before being connected with the subject.

REMOVAL OF VENOUS BLOOD FROM THE RECIPIENT

It should be noted that should the extracorporeal apparatus have a volume of 1500 ml., an individual weighing 30 kg. undergoing an open heart operation would, even at a reduce flow of 50 ml. per kilo of body weight, require a minute volume circulation of 1500 ml.; therefore the blood must pass through the pump-oxygenator in 1 minute. During this minute, the blood must flow from the recipient's veins, be oxygenated, defoamed, filtered, be returned to the pump without applying reduced pressure, and be pumped back into the arterial system at suitable systolic and diastolic pressures. Obviously, such a cycle demands dispatch and efficiency.

The maintenance of a low flow of 50 ml. per kilo per minute requires bleeding from the superior and inferior venae cavae equivalent to approximately 40 per cent of the total blood volume each minute. Since the normal cardiac minute volume is about 55 per cent of the blood volume, it is evident that the cannulating tubes cannot be much smaller than the cavae if the required free flow is accomplished. The bleeding must occur without the application of appreciable suction. Complete by-pass of the heart and lungs frequently results in a progressive decrease of venous return. There is some evidence that this deficiency can be prevented if the right atrium is partially distended, using a rubber balloon so as to avoid the Bainbridge reflex.

Failure of venous return demands the addition of blood to the apparatus in sufficient quantity so as to maintain the arterial flow and a minimum systolic blood pressure of 80 mm. Hg. Neosynepherine or norepinephrine may be indicated to increase peripheral resistance. The venous pressure must be monitored continuously. Its elevation indicates an overloading of the vascular bed or blockage to venous outflow.

The venous blood should be passed to the oxygenator with minimum handling, without delay and without traveling long distances at high velocity.

OXYGENATION AND DECARBONIZATION OF THE BLOOD

Hemoglobin is an amphoteric chemical compound with properties well adapted to the transport of oxygen and carbon dioxide to and from the tissues of the

body. The chemical equilibrium hemoglobin plus oxygen to yield oxyhemoglobin is rapidly established and reversibly. Oxyhemoglobin is unstable and maintains a decomposition pressure of oxygen which is well suited to the transport of oxygen from the alveolar spaces to the extracellular fluid bathing tissue cells. A major portion of the carbon dioxide is carried from the tissue cells to the alveolar membranes of the lungs in combination with reduced hemoglobin. Oxyhemoglobin is a stronger acid than reduced hemoglobin. This property favors the release of carbon dioxide to the alveolar membranes of the lungs.

The oxygenation and decarbonization of blood is in itself no problem. The problem arises when this exchange must be effected with the speed required by the large volumes of oxygenated blood needed to maintain the arterial pressure. The problem would be greatly simplified if the quantity of blood available for treatment in the extracorporeal system was not so limited.

It seems imperative at this moment that blood and its gaseous components must be brought into direct contact by large surfaces to effect the demanded respiratory exchange, because inert membranes of sufficient area and speed of gaseous diffusion are not yet available and hetrologous and homogenous lung membranes are too uncertain in performance.[4] Liquid-gas interfaces can be produced by bubbling gas through the blood, or the blood can be spread into a thin layer in the gaseous atmosphere. If either procedure is done rapidly, foaming will result. The large films of the foam can be broken with the recently available silicone antifoaming agents. The minute bubbles present the problem.[5] They cannot be broken, they will not coalesce sufficiently rapidly, they cannot be removed by bubble traps since these small bubbles rise so slowly and will be swept directly through these contraptions by the rapidly moving stream of blood, but they can be strained out partially by passage through so-called filters. After being transported back to the tissues, there is ample time for these small bubbles and other particulate material to coalesce and form conglomerations of sufficient size to cause local disturbances in the smaller capillaries and tissues. De Wall and more recently Cooley has tried to skim off these small particles by letting the blood run down inclined planes having a low pitch, utilizing a sort of floatation process.[7, 16] None of these procedures are completely effective at high flow rates.

The best practical procedure for adequate oxygenation and decarbonization involves filming of the blood in an atmosphere of oxygen-carbon dioxide by any one of several methods as proposed by Gibbons and Dennis.[8, 15] The flow of the blood must be sufficiently slow as not to cause foaming.

The present authors have found highly efficient oxygenation to occur when the filming surfaces are alternately submerged and removed from the blood. This reciprocating process films the blood and simultaneously serves to pump gases over the films atraumatically. Plastic beads of varying sizes serve as highly effective filming surfaces.

Any procedure used for this purpose must travel the blood a minimum distance. Foaming and whipping of blood is not permissible.

PUMPING OF BLOOD AND TRAUMA TO BLOOD

Early it was thought pumping of blood was simple, but certain factors such as the relative velocity and distance of travel, turbulence, crushing between surfaces, application of suction and abrupt changes in pressure and direction damaged the blood.[8] Contact of blood with some substances, especially certain glasses, interferes with clotting.[10, 20] nonwettable plastics stainless steel or rubber coated with D-C antifoam-A are the better tolerated surfaces for the apparatus. Prolonged pumping of blood leads eventually to the destruction of its ormed elements. The first constituents to be affected are the platelets which may be reduced as much as 50 per cent in 30 minutes.[5] The eosinphiles disappear

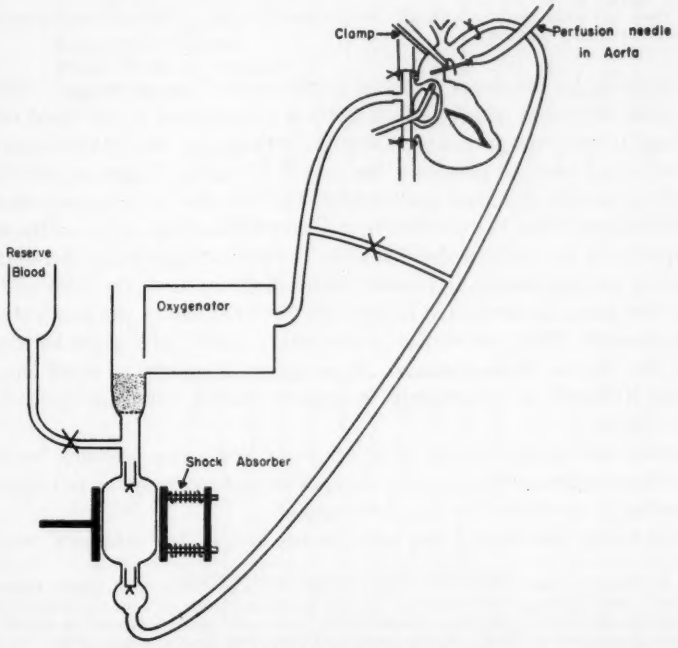


FIG. 1. Diagram of a simplified extracorporeal pump-oxygenator. The cannulae in the venae cavae are as large as practically possible to allow easy free flow of venous blood to the oxygenator. The oxygenator is a device in which the filming surface is submerged into the blood with filming and exposure to oxygen-carbon dioxide on removal from the blood. The submersion and surfacing of the filming material serve to pump the gases over the filmed blood. Plastic beads make an excellent filming material of high surface area.

The pump is an extremely simple device consisting of thin walled plastic tubing supported by a fabric covering and 2 valves described in figure 2. Manual compression of the chamber of the pump is extremely easy and can be done by a single individual by alternating hands without tiring for a period of 30 minutes while maintaining an output of 3500 cc. at a pressure as high as 250 mm. Hg at a pulsation rate of 50 to 75 per minute. The blood travels by gravity only up to the time when it is propelled out of the pump and back to the arterial side of the patient's vascular bed. Foaming does not occur. Oxygenation is efficient.

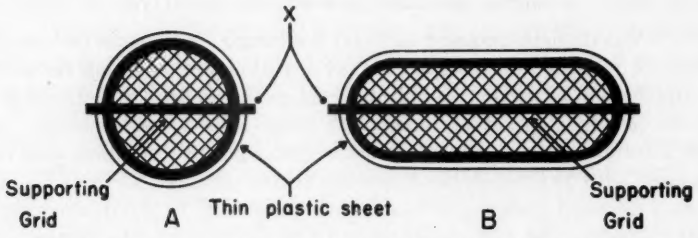


FIG. 2. Cross sections of valve surfaces, *A*, circular, *B*, elongated. X represents the mechanism for fixation of the thin plastic flutter vane across the center of the oriface of the valve. The supporting grid of fine stainless steel wire prevents the inward collapse of the vane against pressure.

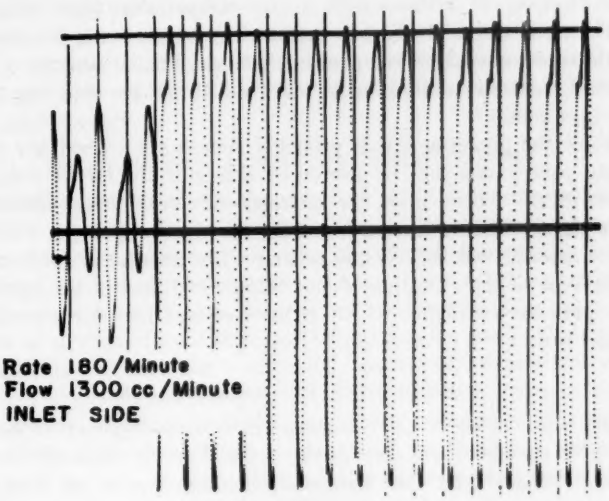
The vane has practically no weight. Its action is rapid, atraumatic and positive and will function in any position.

early probably by becoming attached to the walls of the apparatus.[12] The total white blood cell count usually falls slightly.[22] The number of red blood cells and their fragility are not appreciably altered in 30 minutes. The blood should never be subjected to reduced pressures, because of the great danger of effervescence with the formation of minute gas bubbles. The chamber of the pump should not develop suction on the blood either by positive mechanical action or the restorative capacity of the walls of the chamber. The sigma finger pump develops rapid changes of pressure above and below atmospheric on both the inlet and outlet sides of the pump as illustrated in figure 1. The chamber of the pump should fill only by gravity. The cross section of the intake check valve must be large relative to the volume of the chamber, it should react rapidly to small changes of flow and it should be moderately leak-proof Such a valve has recently been devised, figure 2.

The least trauma is done the blood when pumped by air pressure, because the gas is compressible and the pressure changes are not so abrupt as to import great acceleration to the blood leaving the chamber.

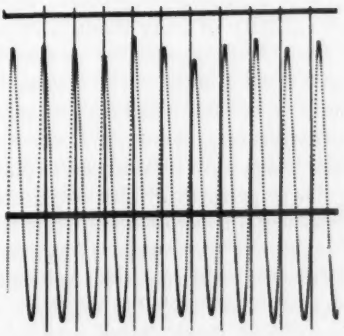
Clowes found that 64 mg. per cent plasma hemoglobin increases result after

FIG. 3. These graphs represent strain gauge readings made on a sigma finger pump using the 1 inch tubing recommended by the manufacturers of this equipment for high volume pumping. The gauges were placed at the inlet and outlet sides of the pump. *A*. The fluid was maintained at 50 mm. Hg hydrostatic pressure on the inlet side of the pump which is represented by the heavy base line in the graph. At the rate of 180 pulsations per minute and a flow of 1300 ml. per minute the pressure wave is complex and doubled. This complexity resists at rates of 300 pulsations per minute and a flow of 3300 ml., but the 2 pressure waves are nearly superimposed. The pressure rises to 260 mm. Hg (50 plus 210) and falls to 215 mm. Hg below atmospheric pressure, i.e., 265 mm. Hg below the 50 mm. Hg base line (265 − 50 = 215). These fluctuations represent a pressure change of 475 mm. Hg being imposed on the blood at the intake side during each cycle of the pump. *B*. Representation of the same data on the outlet side of the pump. The base line in this instance is 120 mm. Hg. The maximum pressure measured is 290 mm. Hg, i.e., 170 mm. Hg above the base line, and a minimum pressure of 15 mm. Hg, i.e., 105 mm. Hg below the base line. The total pressure fluctuation is 275 mm. Hg on the outlet side during each cycle of the pump. In passing through the pump at the flow rate of 3300 ml. per minute, the blood is subjected to pressure fluctuations of 505 mm. Hg; a maximum of 290 mm. Hg above atmospheric and 215 mm. Hg below atmospheric. Subjecting blood to a so-called negative pressure of 215 mm. Hg is extremely hazardous in so far as liberation of small bubbles of gas is concerned.



A

1″ Rubber Tube
Rate = 300/Minute
Flow = 3300 ML/Minute
INLET SIDE
50 mm Hg



B

1″ Rubber Tube
Rate = 300/Minute
Flow = 3300 ML/Minute
OUTLET SIDE
120 mm Hg

FIG 3 *A-B*

blood was pumped 30 minutes with an air compression type pump without valves.[5] The same physical effect is obtained by compressing the chamber between surfaces supported on compression springs. This arrangement allows an easier control of stroke volume. An increase of 134 mg. per cent was noted with the finger type pump.[5]

The rate of the pumping action probably should not exceed the pulse rate. The minute volume can best be altered by changing the stroke volume. Most pumps now in use depend upon the increased rate to increase minute volume, and at the higher volumes the pulse rate is excessively rapid.

Both the arterial and the venous pressures are monitored continuously and a record is kept of the variation of the volume of blood in the extracorporeal system to indicate the degree to which the recipient may have overloading of the vascular bed.

CONTROL OVER ACID-BASE BALANCE

Perfusion with virtually all extracorporeal pump-oxygenators has resulted in measurable metabolic changes in the body. Various elements in the blood reflect these changes. The most significant changes seem to be chiefly confined to the factors regulating acid-base balance.

Pyruvate blood levels during and immediately after perfusion are elevated.[4, 9, 19, 21] Lillihei and others have found an appreciable elevation of blood lactic acid levels.[24] It is interesting, however, that higher blood lactic acid levels have been reported in normal individuals following strenuous exercise than are frequently seen following whole body perfusion. Studies that depend only on pH determination for evidence of acid-base derangement probably give an incomplete picture because of the buffering capacity of body fluids. Generally it has been found that there is a tendency for development of a metabolic acidosis during total body perfusion. This tendency is noted to be especially accelerated with extended time of perfusion using low flows and inadequate maintenance of arterial blood pressure.[6] Some work has been done which shows a delay in the development of acidosis in animals which have been hyperventilated with an atmosphere of nearly pure oxygen prior to perfusion.[22] This observation would indicate that a major factor in development of metabolic acidosis is an inadequate oxygen supply to the tissues. In addition, the increase of the products of metabolism in the blood may indicate lowered renal function. Attempts to assist the body in compensating for the acidosis have included addition of bicarbonate and excessive removal of carbon dioxide, both of which tend to produce a respiratory alkalosis. This points to the importance of striving for an extracorporeal system which will permit maintenance of near normal circulating blood volume and adequate arterial blood pressure levels.[3, 11] Decreased renal function is not the major factor in development of acidosis as shown by the fact that metabolic acidosis may develop when renal function is not measurably lowered.[16, 22] The use of large quantities of citrated whole blood or plasma would greatly aggravate the development of acidosis.[11, 23]

Additional factors influencing development of elevated pyruvate levels are the presence of paracolon bacteremia and use of thiopental sodium for anes-

thesia. An additional factor influencing development of metabolic acidosis is the stress response of the adrenal medulla.

It is readily apparent that many of these factors are the same ones responsible for the usual metabolic change occurring in all patients undergoing general anesthesia and major surgery.

CARDIAC CONTROL DURING OPEN HEART SURGERY

Arrest of cardiac activity during the definitive operative procedure is becoming increasingly popular.[7, 25] The operation can be done more rapidly and accurately. The noncontracting heart muscle can withstand anoxia for as long as an hour without the loss of conductivity or contractility without the use of hypothermia. Furthermore, it is important to occlude the ascending aorta because of the danger of air being forced through the aortic valve should the pressure in the artery fall below 80 mm. Hg even though the left ventricular wall has been incised. If the aorta is occluded without the left ventricle being open, then it is even more important to induce cardiac standstill. Perfusion of the coronaries with 2.5 per cent potassium citrate as practiced by Cooley is probably the method of choice for inducing cardioplegia.[7] Acetylcholine is preferred by some. It may well be advantageous to perfuse the heart continuously with an aerated, balanced and slightly nutrient solution throughout the period of standstill. The heart usually resumes normal rhythm with the return of blood. Gentle massage of the heart will aid in the initial return of blood to the coronary system. Ordinarily the heart activity will have returned while it is still open and recovery will be practically complete before the full work load will be resumed.

THE NEUTRALIZATION OF HEPARIN

Many investigators have remarked on the problem of neutralization of heparin at the conclusion of the perfusion. Hurt, Gerbode, Perkins and Osborne have proposed a method of protamine titration of the heparinized blood considering these factors:

1. The dose of protamine required to neutralize heparin in vivo is not the same as is required for its neutralization in vitro.
2. Preparations of heparin and protamine vary greatly in their effect.
3. The quantity of protamine required to neutralize a given dose of heparin will decrease with increasing time from the point of heparin injection. Their method used a series of test tubes with graduated amounts of protamine to which 1 milliliter of the heparinized blood is added. Utilizing the minimum quantity of the protamine necessary to cause clotting and the patient's estimated blood volume, the protamine needed to neutralize the heparin can be estimated.

Injection of protamine is timed so as not to cause a fall in blood pressure or bradycardia.[17] The neutralization should be controlled by subsequent titrations.

CONCLUSION

Widespread interest and activity have progressively established conditions in the extracorporeal circuits to more closely reproduce those existing in the

normal body with resultant decreased physiologic abnormalities. It can be expected that the procedure will rapidly become greatly simplified and less hazardous.

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REFERENCES

1. Best, C. H., and Taylor, N. B.: Physiological Basis of Medical Practice, ed. 5, Baltimore, Md., Williams & Wilkins Co., p. 263, 1950.
2. Blum, L., Megibow, S. J., and Nelson, W. M.: Parabiotic blood pump, S. Forum, American College of Surgeons, W. B. Saunders Co., 1954.
3. Brown, I. W., Jr., and others: Simple expendable blood oxygen-gas exchanger for ues in open cardiac surgery, Surgery *40:* 100 (July) 1956.
4. Campbell, G. S., Crisp, N. W., and Brown, E. B., Jr.: Total cardiac by-pass in humans utilizing a pump and heterologous lung oxygenator (dog lungs), Surgery *40:* 364 (Aug.) 1956.
5. Clowes, G. H. A., and others: Factors contributing to success or failure in use of pump-oxygenator for complete by-pass of heart and lung, experimental and clinical, Surgery *36:* 557 (Sept.) 1954.
6. Cohen, M., and Lillehei, C. W.: Quantitative study of "azygous factor" during vena caval occlusion in dog, Surg., Gynec. & Obst. *98:* 225 (Feb.) 1954.
7. Cooley, D.: Personal communication.
8. Dennis, C., and others: Development of pump-oxygenator to replace heart and lungs; an apparatus applicable to human patients, and application to 1 case, Ann. Surg. *134:* 709 (Oct.) 1951.
9. DeWall, R. A., and others: Total body perfusion for open cardiotomy utilizing bubble oxygenator, J. Thoracic Surg. *32:* 591 (Nov.) 1956.
10. —— and others: Simple expendable artificial oxygenator for open heart surgery, Surg. Clin. North America, Internat. No., p. 1025 (Aug.) 1956.
11. Dodrill, F. D., Hill, E., and Gerisch, R. A.: Some physiologic aspects of artificial heart problem, J. Thoracic Surg. *24:* 134 (Aug.) 1952.
12. —— and others: Arterialization of blood as it applies to mechanical heart lung apparatus, J. Thoracic Surg. *30:* 658 (Dec.) 1955.
13. —— and others: Use of heart-lung apparatus in human cardiac surgery, J. Thoracic Surg. *33:* 60 (Jan.) 1957.
14. Effler, D. B., and others: Disposable membrane oxygenator (heart-lung machine) and its use in experimental surgery, J. Thoracic Surg. *32:* 620 (Nov.) 1956.
15. Gibbon, J. H., Jr.: Application of a mechanical heart and lung apparatus to cardiac surgery, Minnesota Med. *37:* 171 (March) 1954.
16. Helmsworth, J. A., and others: Artificial oxygenation and circulation during complete by-pass of heart, J. Thoracic Surg. *24:* 117 (Aug.) 1952.
17. Hurt, R., and others: Neutralization of heparin by protamine in extracorporeal circulation, J. Thoracic Surg. *32:* 612 (Nov.) 1956.
18. Kay, E. B., and others: Certain clinical aspects of use of pump-oxygenator, J.A.M.A. *162:* 639 (Oct. 13) 1956.
19. Levowitz, B. S., and others: Mechanical pump-oxygenator for direct vision repair of atrial defects, J. Thoracic Surg. *32:* 647 (Nov.) 1956.
20. Lillehei, C. W., and others: Direct vision intracardial surgery in man using a simple disposable artificial oxygenator, Dis. Chest. *29:* 1 (Jan.) 1956.
21. Spreng, D. S., Jr., and others: Acute metabolic changes associated with employment of pump-oxygenator to supplant heart and lungs, S. Forum (1952) p. 165, 1953.
22. Stokes, T. L., and Gibbon, J. H., Jr.: Experimental maintenance of life by mechanical heart and lung during occlusion of venae cavae followed by survival, Surg., Gynec. & Obst. *91:* 138 (Aug.) 1950.
23. Warden, H. E., and others: Direct vision intracardiac surgery by means of reservoir of "arterialized venous" blood, J. Thoracic Surg. *30:* 656 (Dec.) 1955.
24. Wesolowski, S. A., and Welch, C. S.: Experimental maintenance of circulation by mechanical pumps, Surgery *31:* 769 (May) 1952.
25. Young, W. G., and others: Method for controlled cardiac arrest as an adjunct to open heart surgery, J. Thoracic Surg. *32:* 604 (Nov.) 1956.

EXPERIENCES IN THE SURGICAL CORRECTION OF TRANSPOSITION OF THE AORTA AND THE PULMONARY ARTERY*

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Transposition of the aorta and the pulmonary artery has remained a leading challenge to the cardiovascular surgeon. Nearly every surgical group that has concerned itself with cardiovascular problems has had one or more of its members deeply engrossed in this field.[1, 3, 4, 5, 6] The final chapter is not yet written. Until it is, reports of efforts to correct transpositions are interesting because of light they shed on the physiology of this disease and because they stimulate new ideas which might lead to the next step toward solution of the problem. Recently, a method of surgical correction of transposition of the aorta and pulmonary artery was reported which seemed to provide a reasonable operative risk with satisfactory partial correction of the anomaly.[2] Since that report, the procedure has been performed on 35 patients. This is a report of our experiences, with a review of the types of transposition that we encountered.

ANATOMIC VARIATION IN TRANSPOSITION OF THE GREAT VESSELS

Before attempting the operation clinically, a study was made of all transpositions observed at autopsy at the Children's Memorial Hospital in Chicago, Ill. Seventy-five cases were available for study. It became apparent that the use of the word "transposition" as an all-inclusive term was misleading. Transposition of the great vessels is a type of localized situs inversus deformity, in which the aortic-pulmonary septum that divides the embryonic truncus fails to spiral. As a result, unoxygenated systemic blood returning to the right atrium is transported back to the periphery by way of the aorta. Oxygenated blood returning from the lungs, instead of being sent to the periphery, is transported back to the lungs via the pulmonary artery. However, the deformity does not end there. Other congenital cardiac defects encountered in hearts with normal relationship of the aorta and pulmonary artery are superimposed. For example, most cases of "simple" transposition had patent ductus arteriosus, interventricular septal defects or interatrial septal defects which permitted the patient to survive a few days or months after birth. In addition, transposition of the great vessels was found associated with right aortic arch pulmonary valvular stenosis, coarctation of the aorta, tricuspid valve atresia, isolated dextrocardia, aortic valve stenosis, mitral valve stenosis and infundibular stenosis. In short, an entirely variable collection of congenital cardiac anomalies was encountered—all superimposed

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on the basic defect of transposition of the aorta and pulmoary artery. Five general groups of transposition deformities were identified (table 1).

1. *Simple Transposition of the Great Vessels:* Forty-six specimens (61.3 per cent of the autopsied patients) had transposition of the great vessels without obstruction to blood flow resulting from other superimposed congenital cardiac anomalies. No valvular stenoses, no chamber deformities and no coarctation of the aorta were encountered. Thirty-two of these specimens had significant patent ductus arteriosus, interventricular septal defects, interatrial septal defects or combinations of these communications between the right and left sides of the heart. The remaining 14 specimens had histories suggesting closure of a patent ductus arteriosus or patent foramen ovale just before death. Aside from the above communications and the transposition of the great vessels, all these hearts were basically sound.

2. *Transposition with Pulmonary Valvular Stenosis:* Twelve specimens (16.0 per cent of the autopsied patients) had significant stenosis of the pulmonary valve. Six had bicuspid pulmonary valves, 5 had morphologic valvular stenosis, and one had complete valvular atresia. One patient had infundibular stenosis in addition to the pulmonary valvular stenosis. All had interventricular septal defects. Some also had patent ductus arteriosus or interatrial septal defects. In 3 specimens, the interventricular septal defect was so large that the ventricles functioned as a single chamber, in which extensive mixing of systemic and pulmonary blood probably occurred. In the remaining 9 patients, the interventricular septal defects were smaller, but nevertheless seemed functionally significant.

3. *Transposition with Tricuspid Valvular Stenosis:* Five specimens (6.7 per cent of the autopsied patients) had transposition of the great vessels together with tricuspid valvular stenosis or atresia. Three also had pulmonary valvular stenosis. All had interatrial and interventricular septal defects that probably allowed considerable mixing of the systemic and pulmonary circulations.

4. *Transposition with Coarctation of the Aorta:* Eleven specimens (14.7 per cent of the autopsied patients) had transposition of the great vessels in conjunction with coarctation of the aorta. In 10, the coarctation was infantile. One had the adult type. Two specimens also had stenosis of the mitral valve. One infantile coarctation had an associated aortic valvular stenosis with complete hypoplasia of the aortic arch.

TABLE 1

Anatomic variations in transposition of the great vessels

	Cases	Per Cent
Simple transpositions	46	61.3
Transpositions with pulmonary valvular stenosis	12	16.0
Transpositions with tricuspid valvular stenosis	5	6.7
Transpositions with coarctation of the aorta	11	14.7
Transposition with isolated dextrocardia	1	1.3
Total autopsied patients	75	100.0

5. *Transposition with Isolated Dextrocardia:* One specimen (1.3 per cent of the autopsied patients) had a functional transposition of the great vessels in association with isolated dextrocardia. This case was of extreme interest because isolated dextrocardias are frequently regarded as forms of "corrected" transpositions, in which not only the arteries, but also the veins entering the heart are transposed. In this particular specimen, the veins had failed to follow the situs inversus deformity in the heart, so that the pulmonary and systemic circulations had become separated.

It became apparent from these studies that all transpositions could not be managed exactly alike. Most of them, it is true, were amenable to partial correction by transfer of the right pulmonary veins and the inferior vena cava, to be described below. However, others, with stenosis of the tricuspid valve or with significant pulmonary valvular stenosis, were basically problems in increasing the flow of blood to the lungs. They were logically candidates for shunt operations.

Empirically, it was decided that those patients having pressures in the pulmonary artery of 200 Mm. or more would be treated by transplantation of the right pulmonary veins and the inferior vena cava. Those with pressures less than 200 Mm. would be treated by aortic-pulmonary or subclavian-pulmonary anastomoses. Six patients fell in the latter category. One had transposition associated with tricuspid atresia and 5 had transposition with associated pulmonary valvular stenosis. Two of them were diagnosed preoperatively and had left aortic-pulmonary anastomoses. The remaining 4 had right thoracotomy in preparation for transplantation of the inferior vena cava and the right pulmonary veins, when pressures less than 200 Mm. were unexpectedly encountered in the pulmonary artery. Subclavian-pulmonary anastomoses were performed. One of the 6 patients died in the immediate postoperative period, an operative mortality of 16.7 per cent (table 2). In the survivors, the cyanosis was alleviated.

Transplantation of Right Pulmonary Veins and Inferior Vena Cava: Thirty-five patients with transposition were treated by transplantation of the right pulmonary veins and the inferior vena cava. The operative procedure has been described and illustrated in detail in another publication.[2] It may be summarized as follows:

A posterolateral thoracotomy is performed through the right fifth intercostal space, and the right pulmonary artery, right pulmonary veins, right main bronchus and inferior vena cava are dissected free. The pericardium is opened, ex-

TABLE 2

Operative mortality in transposition of the great vessels

	Total Cases	Survivors	Operative Deaths	Mortality Rate
Partial corrections	35	21	14	40.0%
Shunt operations	6	5	1	16.7%
Totals	41	26	15	36.1%

posing the lateral aspect of the right atrium. Care is exercised to preserve the right phrenic nerve. After the diagnosis is confirmed and pressure of the pulmonary artery is determined if necessary, a curved coarctation clamp is applied to the lateral aspect of the inferior vena cava, in such a way that blood flow from the inferior vena cava to the right atrium is not impeded.

An incision is made in the excluded lip of the inferior vena cava and a homologous aortic graft is anastomosed to the cava, utilizing a continuous no. 00000 arterial silk suture. The right pulmonary artery and the right main bronchus are then occluded with temporary umbilical tape ligatures, in order to prevent congestion of the right lung during the remaining maneuvers.

Coarctation clamps are applied to the base of the right pulmonary veins allowing them to be severed from the left atrium. The opposite end of the homologous aortic graft is then anastomosed to the left atrial stump of the right pulmonary veins. The distal end of the right pulmonary veins is anastomosed to the lateral aspect of the right atrium, a curved coarctation clamp being applied to the right atrium in order to exclude part of its wall for that purpose. Continuous no. 00000 arterial silk suture is used for both these anastomoses.

The temporary umbilical tape ligatures are removed from the right pulmonary artery and the right main bronchus, and the right lung is aerated. After the patient has had a few minutes to adjust to the new circulation, a silk ligature is placed around the point of entry of the inferior vena cava into the right atrium, making flow of blood obligatory from the inferior vena cava through the aortic graft into the left atrium. The pericardium is repaired, endothoracic drainage is provided and the thoracic incision is closed in the usual manner.

Of the 35 patients who were operated upon by this method, 14 died in the immediate postoperative period, an operative mortality of 40 per cent. Twenty-one patients survived and were discharged from the hospital (table 2). The survivors had very satisfactory alleviation of their cyanosis. Most of them had preoperative peripheral oxygen saturation levels ranging from 35 per cent to 60 per cent of capacity. Postoperatively, they demonstrated increases in peripheral oxygen saturation of 35 per cent to 50 per cent, their postoperative oxygen saturation levels averaging 85 per cent–91 per cent. Clinically, they demonstrated

TABLE 3

Causes of operative mortality

Immediate operative deaths	
1. Cardiac failure	5
2. Cerebral vascular accidents	3
3. Hemorrhage from right lung	2
4. Right pulmonary edema with anoxia	2
5. Intercostal hemorrhage	1
6. Supraventricular tachycardia	1
Delayed operative deaths	
1. Diarrhea	1
2. Pulmonary arteriolar sclerosis	1
3. Bronchopneumonia	1

no cyanosis at rest and had only slight blueness of the lips and nail beds after severe exercise. During the first 3–4 months following operation, the surviving patients demonstrated marked increase in exercise tolerance and visible increase in muscle mass of the thighs and calves. Those who had suffered from episodes of syncope no longer had those attacks. Those who had hepatic enlargement and ascites before operation had recession of the liver and disappearance of ascites. The youngest patient surviving this operation was 6 weeks of age. The oldest was 12 years old.

Analysis of Operative Deaths: Fourteen patients died in the immediate postoperative period. Eight of these deaths were related to the patient's disease and in all probability were unavoidable. Six of these deaths resulted from technical difficulties and probably can be prevented in the future.

The unavoidable deaths fell into two categories. Three patients died of cerebral anoxia, never regaining consciousness in the immediate postoperative period (table 3). Five patients died from various types of cardiac failure. One of these, whose heart was markedly enlarged preoperatively and who had had two previous episodes of cardiac failure, developed cardiac dilatation and asystole during the operative procedure. Two others died with bilateral pulmonary edema and enlarged liver during the first postoperative day. The fourth died, 9 days postoperatively, of definite right ventricular failure—demonstrating distension of the superior vena cava and unilateral right pulmonary edema. The fifth died of ventricular fibrillation in the midst of the operative procedure.

Four of the 6 preventable deaths were related to inadequate control of the increased pressure in the pulmonary artery. One patient, early in the series, died of severe hemorrhage into the tracheobronchial tree. The pulmonary artery had been occluded, but the bronchus and bronchial arteries were left open. Apparently, the bronchial arteries had dilated as a compensatory mechanism for the transposition and, during the half hour of occlusion of the right pulmonary veins needed to transfer them to the right atrium, the lung became filled with blood. This blood extravascated into the pulmonary alveoli and interfered with respiration. Incidently, since this death occurred, the bronchus and bronchial arteries are temporarily occluded with umbilical tape along with the pulmonary artery. Two other deaths, occurring in infants, were characterized by the appearance of small amounts of hemorrhagic frothy sputum in the tracheobronchial tree early during the operative procedure. This did not seem alarming and disappeared after occlusion of the pulmonary artery. Apparently, however, manipulation of the infant lung during dissection of the pulmonary vessels and inferior vena cava occluded the pulmonary artery in the face of increased pulmonary pressure and produced enough postoperative pulmonary edema to reduce the infants' lung function to dangerous levels. Since infants in general have little pulmonary reserve, such reduction in respiratory function served to produce anoxia, shock and death in the immediate postoperative period. Since these 2 deaths, the pulmonary artery is isolated and occluded in infants immediately after the thoracotomy incision is opened. Pulmonary edema has been greatly reduced and their immediate postoperative course has improved considerably.

The fourth death from pulmonary complications illustrates how treacherous a markedly elevated pressure in the pulmonary artery can be. This death occurred in a 3 year old transposition who was a satisfactory operative risk and who tolerated the operative procedure well. Pressure in the pulmonary artery, however, was very high. After release of the pulmonary artery, the manipulation of the lung necessary to restore hemostasis and to return the lung to its proper place in the pleural cavity resulted in enough pressure to rupture the pulmonary capillaries and cause severe pulmonary hemorrhage. Since chronic hepatic anoxia had produced some obscure type of interference with blood coagulability, the pulmonary hemorrhage continued in spite of repeated temporary occlusion of the pulmonary artery, until the patient died.

The last 2 preventable deaths occurred from intercostal hemorrhage and supraventricular tachycardia respectively. In the former, a bleeding point in an intercostal vein was not detected during the operative procedure, because reduction in blood flow resulting from hypothermia. Intrapleural hemorrhage occurred in the immediate postoperative period and this was not detected in time to save the infant's life. In the latter, the use of hypothermia resulted in supraventricular tachycardia. Several hours elapsed before this abnormal rhythm could be corrected. By that time, the heart was exhausted and the patient ultimately died of cardiac failure.

Three patients who survived the immediate postoperative period and went home, died later of causes unrelated to the operative procedure. One died of severe diarrhea. Another died rather suddenly of anoxia secondary to pulmonary arteriosclerosis. The third died of extensive bronchopneumonia. His lungs also showed severe pulmonary arteriosclerosis.

SUMMARY

A study is presented of clinical application of a recently developed procedure for partial correction of transposition of the aorta and pulmonary artery, by transplantation of the right pulmonary veins and the inferior vena cava. Thirty-five patients were operated upon with 21 survivors.

Postoperative clinical improvement seemed very satisfactory, the oxygen saturation rising from 35 per cent–60 per cent preoperatively to 85 per cent–91 per cent postoperatively, a net improvement in oxygen saturation of 35 per cent–50 per cent.

Study of the pathology of transposition of the great vessels revealed that this procedure could not be applied to all transpositions. Those few with tricuspid stenosis or significant pulmonary valvular stenosis were successfully treated with shunt operations.

Analysis of the causes of operative deaths is made, dividing them into preventable and nonpreventable deaths. Emphasis is placed on postoperative difficulties which may be avoided in the future.

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REFERENCES

1. Albert, H. M.: Surgical correction of transposition of great vessels, S. Forum 1954; Am. College Surgeons, p. 74, Philadelphia, W. B. Saunders Company, 1955.
2. Baffes, T. F.: New method for surgical correction of transposition of aorta and pulmonary artery, Surg., Gynec. & Obst. *102:* 227 (Feb.) 1956.
3. Bjork, V. O., and Bouckaert, L.: Complete transposition of aorta and pulmonary; experimental study of surgical possibilities for its treatment, J. Thoracic Surg. *28:* 632 (Nov.) 1954.
4. Blalock, A., and Hanlon, C. R.: Surgical treatment of complete transposition of aorta and pulmonary artery, Surg., Gynec. & Obst. *90:* 1 (Jan.) 1950.
5. Murphy, T. O., Gott, V., Lillehei, C. W., and Varco, R. L.: Results of surgical palliation in 32 patients with transposition of great vessels, Surg., Gynec. & Obst. *101:* 541 (Nov.) 1955.
6. Mustard, W. T., and others: Surgical approach to transposition of great vessels with extracorporeal circuit, Surgery *36:* 39 (July) 1954.

EDITORIAL

RESECTION OF THE CORD IN INGUINAL HERNIA REPAIR

The question is often asked: How often is it necessary to remove the testicle in inguinal hernia repair? Our answer is, "Never—the cord occasionally, but the testicle, never, or almost never."

In the first place, few patients will agree to the removal of the testicle. This, in spite of the fact that a great many surgeons believe that it is necessary to remove it in certain recurrent hernias, especially in those that have been several times recurrent, in order to effect a cure. Surgeons believing this way often refuse to operate unless the patient agrees to orchidectomy, and thereby often lose their patient. It is useless to tell these patients that they will get along just as well with one testicle as with two. Even if they can get along physiologically just as well with one as with two, a great many patients still consider unilateral orchidectomy to be surgical mayhem. A few, with unpardonable lack of pride, will say, "Go ahead and take it—it's no good to me anyway". But they are the exception. One of our colleagues got his patient to agree to the sacrifice of a testicle, but his wife objected. When the surgeon tried to explain to the patient's wife that he (the patient) didn't need the testicle, she said, "I know, doctor, but it makes him look so dressy."

The only reason for removing the testicle is to dispense with the cord. Probably the presence of the cord is the greatest obstacle to the cure of inguinal hernia in the male. This structure is undoubtedly responsible for the far greater number of inguinal hernias in the male than the female. In spite of this, we believe that most inguinal hernias in the male can be cured without sacrificing the cord.

In an occasional recurrent hernia (generally one that has several times recurred), the cord comes through the internal ring through a mass of scar tissue of such cartilaginous consistency that proper closure of the structures around the cord is impossible. When this is true, the presence of the cord is a real deterrent to the cure of the hernia, and, if left in place, it would invite another recurrence. In such cases, the cord may simply be transfixed and ligated at both the internal and external rings and the intermediate portion resected. Unless the testicle has been removed from its bed, the collateral circulation of that organ will not have been interfered with and atrophy is rare. Removal of the cord allows full utilization of the tissues around the internal ring in closing the defect in that area.

Burdick and Higinbotham, in 1935, reported 200 cases in patients who were operated upon with resection of the cord. A few of the testicles atrophied and some completely disappeared, but it was surprising how many remained apparently normal. Gangrene did occur, however, in 4 of the 200 patients. Grace and Johnson pointed out that necrosis of the testicle occurs only when it is disturbed from its normal attachments during the operation.

One source of the collateral circulation is in the inguinoscrotal region just beyond the external ring where branches of the vesical or prostatic arteries,

passing under the arch of the pubis, may furnish some of the circulation to the testicle. Another source of collateral circulation is at the lower extremity of the testicle, where the scrotal arteries anastomose with the internal spermatic and deferential arteries.

In those patients in whom atrophy does occur, it is probable that the cord has been dissected free too far beyond the external ring, thus interfering with the collateral circulation. Undoubtedly there are individual anatomic variations also, which account for the atrophy of the testicle in some instances, but not in others.

Following excision of a section of the cord, some swelling and tenderness of the testicle does occur, but this generally subsides within a few days. A suspensory should be worn during the troublesome period. An ice cap also helps.

Considering the difficulties in securing permission for removal of a testicle in hernia repair and the legal difficulties which one might get into if a testicle were removed without having secured permission, it seems obvious that the simplest way out, in the occasional patient in whom the cord does interfere with the cure of the hernia, is a simple resection of a segment of the cord. It is true that one may get an occasional atrophy of the testicle, but then what surgeon hasn't gotten an occasional atrophy of the testicle after a simple hernia repair in which neither the cord nor the testicle had been unduly tampered with? Here again, I believe that anatomic variations in the circulation are responsible, because every surgeon knows that ordinarily the structures may be closed very tightly about the cord without impairing its circulation. This is borne out by the fact that the cord may even be transected without atrophy of the testicle.

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BOOK REVIEW

The editors of THE AMERICAN SURGEON *will at all times welcome new books in the field of surgery and will acknowledge their receipt in these pages. The editors do not, however, agree to review all books that have been submitted without solicitation.*

Surgery for General Practice. By VICTOR RICHARDS, Professor of Surgery, Chairman of Department of Surgery, Stanford University School of Medicine, San Francisco, California. The C. V. Mosby Company, 1956, St. Louis, Price, $17.50.

This new text is designed for use by the practitioner of medicine whether he be a general practitioner, a student or a specialist. It is a text that is meant to organize the individual's thoughts along the line of surgery and is not designed to encumber the individual's mind with masses of detail. The aim is a valiant one. The text begins with a chapter on local anesthesia and is followed by chapters on hemorrhage, shock, surgical injury, infection, burns, etc. All in all there are some 43 chapters on the specialties seen in surgery. The text is excellent on each topic particularly in that the subject matter covered is done extremely well and is quite concisely discussed. There is a proficiency of many excellent photographs and illustrations.

The great advantage of this text is that many of the illustrated material is in the form of line drawings excellently executed and well reproduced. These line drawings illustrate very well the points made in the text.

The index and method of organization of the chapters leads to an ease in locating material needed. There is not too great a space spent dealing with surgical technic and this is as it should be since this is designed as a text to organize thought rather than describe the details of treatment.

The text is recommended for the general practitioner's shelf and serves as an excellent refresher to the practicing surgeon. Perhaps the book is a little too brief to be considered sufficient as a textbook in surgery for the average medical student however, it is an excellent guide in teaching of the specialties of surgery.

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